Marine Environmental Data Service

A Comparison of Hindcast and Recorded Wave Data

W.F. Baird and J.S. Readshaw
W.F. Baird & Associates, Coastal Engineers Ltd.

CONTRACTOR REPORT NO. 1

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DEPARTMENT OF FISHERIES AND OCEANS
OTTAWA, CANADA

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Marine Environmental Data Services Branch, Ocean Science and Surveys, Department of Fisheries and Oceans, Ottawa, Ontario. K1A 0E6.

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ABSTRACT

A comparison is made of hindcast and recorded wave data for the east coast of Canada. Wave heights and periods as measured by Waverider buoys are compared to hindcast waves produced by the U.S. Corps of Engineers spectral model developed by D. T. Resio. The performance of the model for individual storms is discussed, and recommendations for further comparison work are presented.

RESUME

Des rétroprévisions et des données enregistrées sur les vagues sont comparées pour la côte est du Canada. On compare la hauteur et la période des vagues mesurées par les bouées Waverider aux rétroprévisions fournies par le modèle spectral du l'U.S. Corps of Engineers mis au point par D. T. Resio. Le rendement du modèle pour des tempêtes isolées est examiné et on formule des recommandations pour d'autres comparaisons.

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1 INTRODUCTION

The design of structures and operations associated with the exploration and recovery of oil and gas in the Labrador Sea, the Grand Banks, and the Nova Scotian shelf requires extensive oceanographic data.

An accurate description of the wind generated wave climate of these areas is essential to an assessment of the efficiency of the operations and the safety of the structures.

There are three sources of wave data available, as follows:

(i) Wave data recorded for relatively short periods (of the order of 1 or 2 months) at many different locations since 1972.

(ii) Observations of waves reported by officers of ships passing through the areas. Many million of these data have been archived for the north Atlantic since the early 1900's.

(iii) Wave data hindcast from historical meteorological records. Hindcast wave data that are readily available (March 1981) are as follows:

- Data forecast by the METOC centre Halifax and combined with ship observations for the preparation of maps showing the severity of wave conditions throughout the north west Atlantic. These data have been archived since 1970.

- Data hindcast for the north Atlantic by the Fleet Numerical Weather central, Monterey, California. A deep water wave spectral climatology has been developed for the twenty year period 1956-1975. (Lazanoff and Stevenson 1977).

- Data hindcast for the north Atlantic by the U. S. Corps of Engineers, Waterways Experiment Station for the period 1956-1975.

This report provides a limited evaluation of the latter data, hindcast by the U. S. Corps of Engineers. The evaluation is based only on a comparison of the hindcast wave data with wave data recorded in the general vicinity of a hindcast station.

The accuracy of the hindcast data in defining the wave climate of the Labrador Sea, the Grand Banks and the Nova Scotian Shelf is discussed. Recommendations are made concerning the future use of this model in providing a description of the wave climate of these areas.

2 DESCRIPTION OF THE HINDCAST WAVE DATA

The wind-wave hindcast model was developed by Dr. D. T. Resio and Dr. C. L. Vincent of the U. S. Corps of Engineers, Waterways Experiment Station, Vicksburg during 1978-79.

Details of the model, including a description of the source terms used and the propagation schemes, are described in Vincent and Resio, 1979.

The wind fields, used in the production of the wave statistics described in this report, were derived from pressure data defined on an, approximately, 80 km grid for storms and on a larger grid for other conditions. Ship observations of wind speed were blended into the derived wind field.

The model has been used with these wind fields to hindcast waves for the north Atlantic for the period 1956-75. However, data have been archived for only a limited number of grid points, or stations, in the vicinity of the Labrador Sea, the Grand Banks, and the Nova Scotian shelf. The locations adjacent to the areas of interest are shown in Figure 1. It will be noted in Figure 1 that there are other grid points, where data have not been archived, that are much closer to the locations of the wave recorders used for the comparison contained in this report. For the Labrador Sea the grid points where the hindcast data were archived are many hundreds of kilometres distant from the wave recorder locations and comparison with these recorded wave data was not undertaken.

The hindcast model does not consider any effects of shallow water on wave propagation and it only contains a crude definition of the shoreline, as illustrated in Figure 1. For example both Sable Island and the Avalon Peninsula of Newfoundland are not included in the model. Consequently the hindcast wave data cannot be expected to compare well with the recorded data at locations where the shoreline or shallow water have significantly influenced the recorded wave data.

The available hindcast wave data consist of a description of the directional wave spectra at 6 hour intervals and of parameters describing the local sea state and swell at either 3 hour or 6 hour intervals.

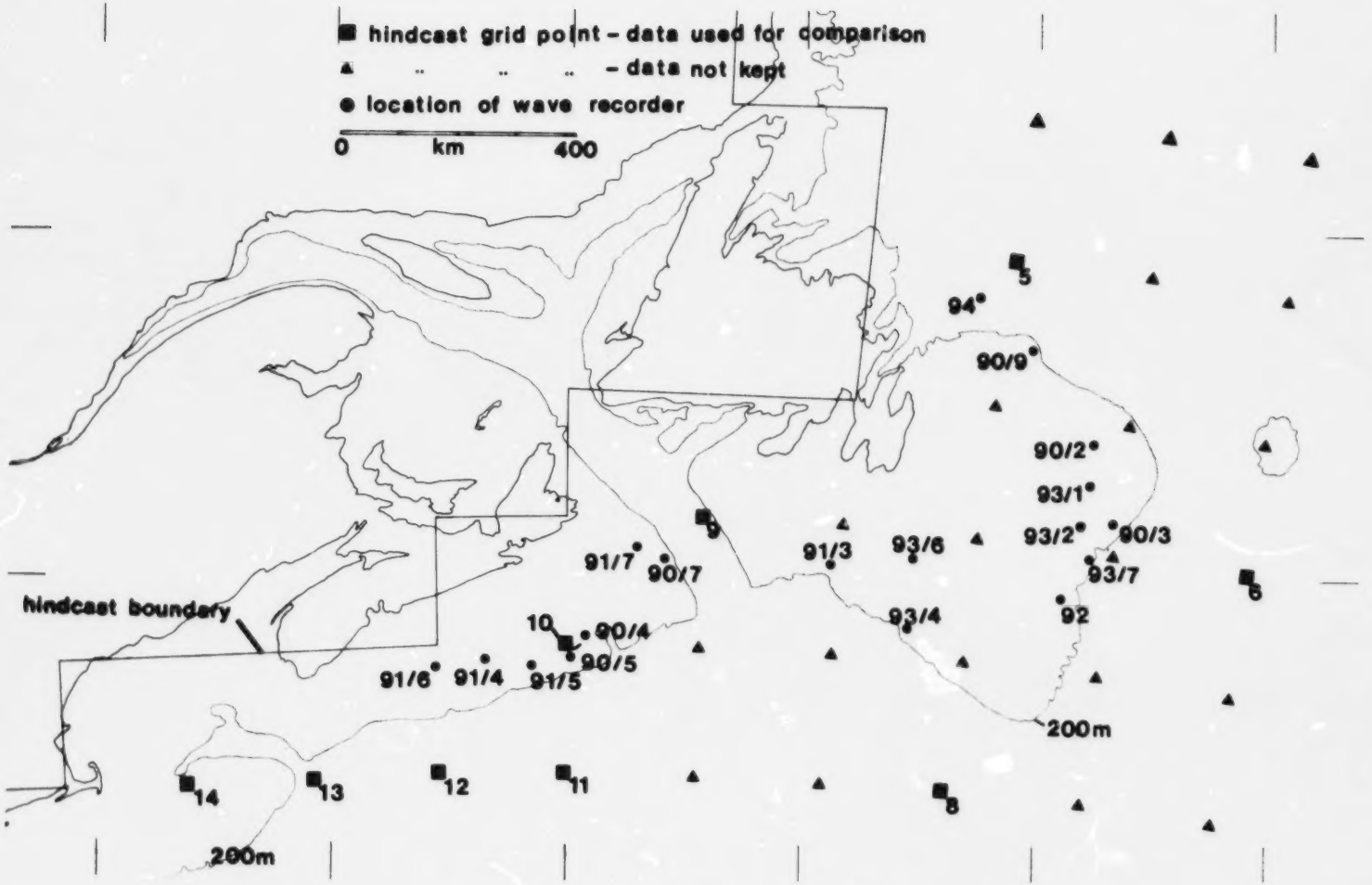

hindcast grid point – data used for comparison
– data not kept
location of wave recorder
0 km 400
hindcast boundary
200m
200m
94
90/9
90/2
93/1
93/2
90/3
93/7
92
93/4
93/6
91/3
91/7
90/7
90/4
90/5
91/6
91/4
91/5
10
5
9
6
14
13
12
11
8

Figure 1

For this comparison only the parametric description of the sea state was used. The parameters available were as follows:

- significant wave height of the locally generated sea state
- period of the locally generated sea state (assumed to be equivalent to the peak period)
- mean direction of travel of the locally generated waves
- significant wave height of the swell
- period of the swell
- mean direction of travel of the swell

A definition of these parameters or details of the hindcast procedure was not available during this comparison. For this study comparison is made with recorded wave data described by the significant wave height, calculated by numerical integration of the variance spectrum and the peak period of the recorded wave spectrum. The recorded wave data are discussed in section 3.

In order that comparison could be made with the recorded data, the hindcast local sea state and swell were combined as follows:

Significant wave height $Hs = \sqrt{Hs_{sea} + Hs_{swell}}$

Peak period $Tp = Tp_{sea}$ or Tp_{swell}, which ever has the largest value. (It would have been preferable to have used the value of Tp associated with the largest value either Hs_{sea} or Hs_{swell}. In fact, for some 95% of the values during storms this was the case.)

Following completion of the hindcast it was established that the wind field was incorrectly defined for northern latitudes during certain periods.

Consequently these periods of the hindcast were repeated. These revised data, for the periods October 1972 to March 1973, and October 1973 to March 1974, were used for this comparison. They were only available for the grid locations that are numbered 5, 6, and 8 in Figure 1.

3 DESCRIPTION OF THE RECORDED WAVE DATA

A large number of wave records have been obtained in the Labrador Sea, the Grand Banks and the Nova Scotian Shelf since 1972. The waves were recorded using Datawell waverider accelerometer buoys with receivers located on exploratory drill rigs. The resulting data are processed and archived by the Marine Environmental Data Services Branch of the Department of Fisheries and Oceans.

The receivers record wave data for 20 minutes every three hours on reel to reel magnetic tape. The 20 minute records are later digitized and the variance spectra calculated. The resulting data are considered to be accurate measurements of the sea state. The recording buoys and receiver systems are verified before and after installation. The buoy is held on station with a single point mooring and in some cases this is of the order of 1000 m long. Some experiments have been performed by MEDS to compare the performance of the waverider buoys with different types of moorings and no evidence was found that the measurements were affected by the moorings.

The recorded wave data used in this comparison are summarized in table 1. Table 1 also shows the hindcast grid points with which the data is compared and the period of the comparison that is possible.

TABLE 1.
DETAILS OF RECORDED AND HINDCAST
WAVE DATA USED IN COMPARISON

RECORDER LOCATIONS			HINDCAST GRID POINT		DATES OF COMPARISON
Name	Number	Depth (m)	Number	Depth (m)	DD/MM/YY
SEDCO J	90 (2)	91.4	6	3830	12/10/73 - 26/11/73
SEDCO J	90 (3)	107.8	6	3830	08/12/73 - 30/12/73
SEDCO J	90 (4)	58.5	10	Sable Is.	25/02/74 - 19/04/74
SEDCO J	90 (5)	36.5	10	Sable Is.	14/06/74 - 11/08/74
SEDCO J	90 (6)	112.8	10	Sable Is.	26/10/74 - 31/10/74
SEDCO J	90 (7)	98.8	9	300	22/01/75 - 31/01/75
SEDCO J	90 (9)	not avail	5	320	08/08/75 - 13/09/75
SEDCO H	91 (3)	120.0	9	300	01/12/73 - 31/01/74
SEDCO H	91 (4)	79.1	10	Sable Is.	01/02/74 - 28/02/74
SEDCO H	91 (5)	92.3	10	Sable Is.	01/03/74 - 19/05/74
SEDCO H	91 (6)	92.3	12	Sable Is.	19/05/74 - 30/06/74
SEDCO H	91 (7)	109.7	9	300	04/07/74 - 31/07/74
SEDNET H	92	58.5	6	3830	11/09/73 - 15/10/73
SEDCO I	93 (1)	85.9	6	3830	01/08/73 - 11/09/73
SEDCO I	93 (2)	not avail	6	3830	11/09/73 - 15/10/73
SEDCO I	93 (4)	85.9	8	4000	01/12/73 - 22/12/73
SEDCO I	93 (6)	85.9	8	4000	28/04/74 - 31/07/74
SEDCO I	93 (7)	84.7	6	3830	01/09/74 - 24/09/74
HAVDRILL	94	335.3	5	320	09/07/74 - 03/10/74
HAVDRILL	94	335.3	5	320	11/06/75 - 11/08/75

4 COMPARISON OF THE HINDCAST AND RECORDED WAVE DATA

4.1 Procedure

The comparison of the hindcast and recorded wave data consisted of the following steps:

1/ Prepare time series plots of all wave data recorded on the Grand Banks and Nova Scotian Shelf, by location. Present on the same diagrams the hindcast wave data from the nearest grid location.

For each wave recorder location the closest hindcast grid point where data had been archived was selected. In the Labrador Sea the hindcast locations available were many hundreds of kilometres distant from the wave recorder locations and, therefore, comparisons for Labrador Sea data are not presented.

These plots are presented in Appendix A and discussed in section 4.2

2/ Select storms from the presentations noted in 1/ above and prepare histograms showing the distribution of wave heights occurring during the storms.

3/ Select the maximum value of the significant wave height from the hindcast and recorded data for each storm when the significant wave height was greater than 5m, and compare these values.

4/ Prepare a discussion of the above presentations while reviewing synoptic weather maps to assist in understanding the features of each storm.

4.2 Plots comparing hindcast and recorded wave data

The following are some brief notes on the comparison plots contained in Appendix A. These notes should be referred to when reviewing the comparisons in Appendix A. Figure 1, showing the locations of the hindcast grid points and the wave recorder locations, will also be useful when reviewing these comparisons. Greenwich mean time is used in the presentation in Appendix A.

The format used in these notes is as follows:

Month, Year Hindcast station No. vs. Recorder station No.
(distance between stations in kilometres)
(the letter A adjoined to a hindcast station No. indicates data from the revised hindcast)

* indicates that a histogram for a selected storm is presented in Appendix B.

General Comments on the Storm

Poor = difference between hindcast and recorded data is consistently greater than 1 m during an approximately 12 to 24 hour period while wave conditions are largest during each storm

Good = difference between hindcast and recorded data is consistently less than 1 m during an approximately 12 to 24 hour period while wave conditions are largest during each storm

Poor/Good = in some storms comparison is poor, in others, good

n1-n2 = difference between hindcast and recorded data during the peaks of storms is between n1 and n2 metres.

July 1973 6 vs. 92 (300km)
Limited recorded data describing low wave conditions (Hs = 1 - 2 m)

Aug 1973

6 vs. 92 (300 km)
A number of small storms (max Hs = 4 m)
Poor
1.5 - 2.5 m

6 vs. 93(1) (292 km)
Poor
Limited recorded data available describing
two small storms

Sep 1973

6 vs. 93(1) (292 km)
*
Three storms, with winds from the north
Poor
2 - 2.5 m

6 vs. 93(2) (279 km)
Limited recorded data available (Hs = 1 - 4 m)
Poor
1.5 - 2.5 m

6A vs. 93(2) (279 km)
*
Storm at 0600Z, Oct 1 consisted of a large low
centered 900 km NE of Newfoundland
Storm at 0600Z, Oct 10 consisted of a large low
centered 200 km E of Newfoundland
Poor
2 - 3 m

Oct 1973

6A vs. 90(2) (328 km)
**
Storm of Oct 28 was tropical storm Gilda in
extratropical stage, at 1200Z the low was centered
300 km E of Newfoundland
Poor/Good/Poor/Poor
0.9 - 2 m

Nov 1973

6A vs. 90(2) (328 km)
* * * *
Storm at 1200Z, Nov 13 consisted of a low centered
400 km SE of Newfoundland
Poor
1.5 - 3 m

Dec 1973 8A vs. 93(4) (272 km)
*
Limited recorded data available describing one storm
(max Hs = 4 m)
Good/Poor
0 - 1.5 m

9 vs. 91(3) (220 km)
* * * * *
Series of large storms, all overestimated by hindcast
At 1200Z on Dec 11 a low over Labrador and a high
SE of Newfoundland produced southerly winds
At 1200Z on Dec 12 winds continued from south
At 0000Z on Dec 19 winds continued from south
At 0000Z on Dec 23 winds continued from south west
At 1800Z on Dec 24 low pressure is centered on the
middle of the south coast of Newfoundland
Poor
1 - 5 m

6A vs. 90(3) (231 km)
*
Significantly better comparison than between
9 and 91(3) above
Good/Poor
0 - 2 m

Jan 1974 9 vs. 91(3) (220 km)
* * * * *
Good comparison except for storm recorded on Jan 9
At 1200Z on Jan 3 a large low NE of Newfoundland
produced north west winds
At 0600Z on Jan 9 a low was centered 500 km NE of
Newfoundland
Good/Poor/Good/Good
0 - 3.5 m

Feb 1974

10 vs. 91(4) (128 km)
* *
At 0600Z on Feb 5 a large low was centered 400 km south of Halifax
At 0600Z on Feb 6 this low was centered 200 km NE of Sable Island
During 19-27 Feb recorded data appear to have incorrect date
Synoptic weather maps show low over southern Newfoundland during Feb 25 and 26
Good/Poor/Poor
0.5 - 1.5 m

10 vs. 90(4) (33 km)
Limited recorded data available describing low wave conditions (Hs = 1 - 2 m)
Good
0.5 - 1.0 m

Mar 1974

10 vs. 90(4) (33 km)
At 1800Z on Mar 5 the wind blew from the SW and station 90(4) was protected by Sabel Island
At 0600Z on Mar 11 the wind blew from the north
At 1800Z on Mar 17 the wind blew from the south and south west and some protection to 90(4) was provided by Sable Island
Poor
1.5 - 6.5 m

10 vs. 91(5) (64 km)
See comments for 10 vs. 90(4), 91(5) was located to the SW of Sable Island
Poor/Good
0.5 - 4 m

Apr 1974

10 vs. 90(4) (33 km)
A series of four small storms with waves from the south. 90(4) was protected by Sable Island during all of these storms
Poor
2 - 3 m

10 vs. 91(5) (64 km)
* * * *
See comments above for 10 vs. 90(4), 91(5) was located to the south of Sable Island
Good/Good/Poor/Good
0 - 1.5 m

8 vs. 93(6) (380 km)
Limited recorded wave data available describing low wave conditions (Hs = 1 - 2 m)

May 1974

8 vs. 93(6) (380 km)
Limited recorded wave data available describing one small storm (max Hs = 3 m)
Good
0.5 - 1 m

10 vs. 91(5) (64 km)
A series of small storms (Hs = 1 - 4 m)
Good/Poor
0.5 - 2.5 m

12 vs. 91(6) (172 km)
*
Synoptic maps indicate that recorded data has incorrect date
At 0600Z on May 29 low is centered over Sable Island
Good
0.5 m

Jun 1974

10 vs. 90(5) (20 km)
Good comparison for low wave conditions
Good
0.5 - 1 m

12 vs. 91(6) (172 km)
Low wave conditions (Hs = 3 m) throughout the month
Good/Poor
1 - 2 m

8 vs. 93(6) (380 km)
Relatively low wave conditions throughout the month (Hs = 1 - 4 m)
Good/Poor
0 - 1.5 m

Jul 1974

9 vs. 91(7) (115 km)
Low wave conditions (Hs = 0.5 - 3 m) throughout the month
Good
0.5 - 1 m

5 vs. 94 (82 km)
See comments above 9 vs. 91(7)
Good/Poor
0 - 1.5 m

10 vs. 90(5) (20 km)
See comments above 9 vs. 91(7)
Poor/Good
0 - 2 m

8 vs. 93(6) (380 km)
Limited recorded wave data available

Aug 1974	5 vs. 94 (82 km) Low wave conditions throughout the month (Hs = 0.5 - 3.5 m) Poor/Good 0.9 - 2 m
	10 vs. 90(5) (20 km) See comments for 5 vs. 94 Poor 2 m
Sep 1974	6 vs. 93(7) (256 km) Limited recorded data describing a series of small storms (max Hs = 4 m) Poor/Good 0.9 - 2 m
	5 vs. 94 (82 km) * At 1200Z on Sep 27 a low is centered 300 km east of Newfoundland Poor/Good 0 - 1.5 m
Oct 1974	5 vs. 94 (82 km) Limited recorded wave data available for low wave conditions (Hs = 2 m)
Jan 1975	9 vs. 90(7) (90 km) Limited data describing three storms (max Hs = 6 m) Poor/Good 0 - 1.5 m
Jun 1975	5 vs. 94 (82 km) Limited data describing three small storms (max Hs = 4 m) Poor 1.5 - 2 m

Jul 1975 5 vs. 94 (82 km)
Recorded data show no wave activity while hindcast data indicate a series of small storms (max Hs = 3 m)
Poor
1.5 - 2 m

Aug 1975 5 vs. 94 (82 km)
Limited wave data describing low wave conditions (Hs = 1 m)
Good
0.5 - 1 m

5 vs. 90(9) (146 km)
**
At 0000Z on Aug 24 a low is centered 300 km east of Newfoundland
Good/Poor
0 - 2 m

Sep 1975 5 vs. 90(9) (146 km)
Recorded wave data show Hs = 2 m while hindcast data show three small storms (max Hs = 4 m)
Poor
1.5 - 2 m

4.3 Histograms showing the frequencies of occurrence of wave heights during storm events

These comparisons are contained in Appendix B and are self explanatory. They will be referred to when the comparisons provided in Appendix A are being reviewed with the assistance of the notes contained in Section 4.2.

4.4 Comparison of the maximum value of the hindcast and recorded significant wave height during each storm event

The results of this comparison are presented in Figure 2, 3, and 4.

In Figure 2, all data for storms when the maximum value of the significant wave height of either the hindcast wave data or the recorded wave data exceeded 5 m. The data recorded close to Sable Island that are obviously influenced by Sable Island are not included.

In Figure 3, the data recorded to the north, east, and south of the Grand Banks and to the north of the Nova Scoatian Shelf are compared with hindcast grid points 5, 6, 8, and 9 respectively.

In Figure 4, the data recorded at station 91(3) are compared with data hindcast for grid point 9 (west of Grand Banks). This comparison also shows the difference between the data recorded in Nov 1973 and Jan 1974.

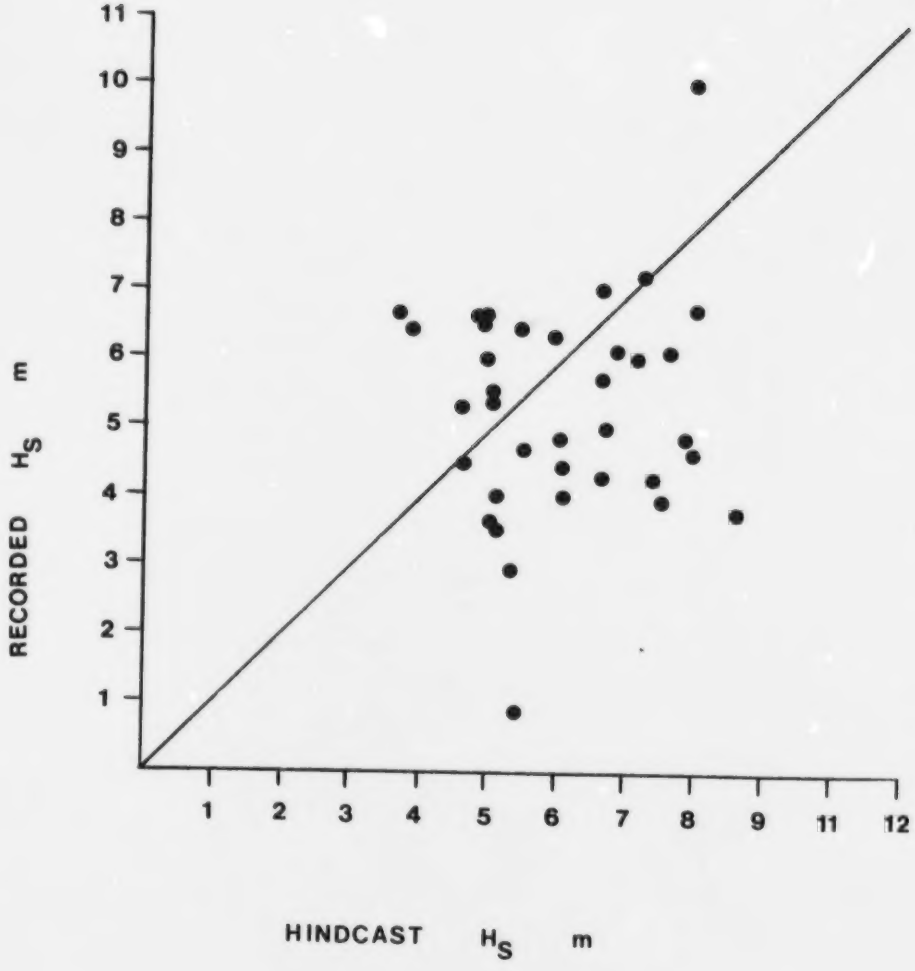


Figure 2

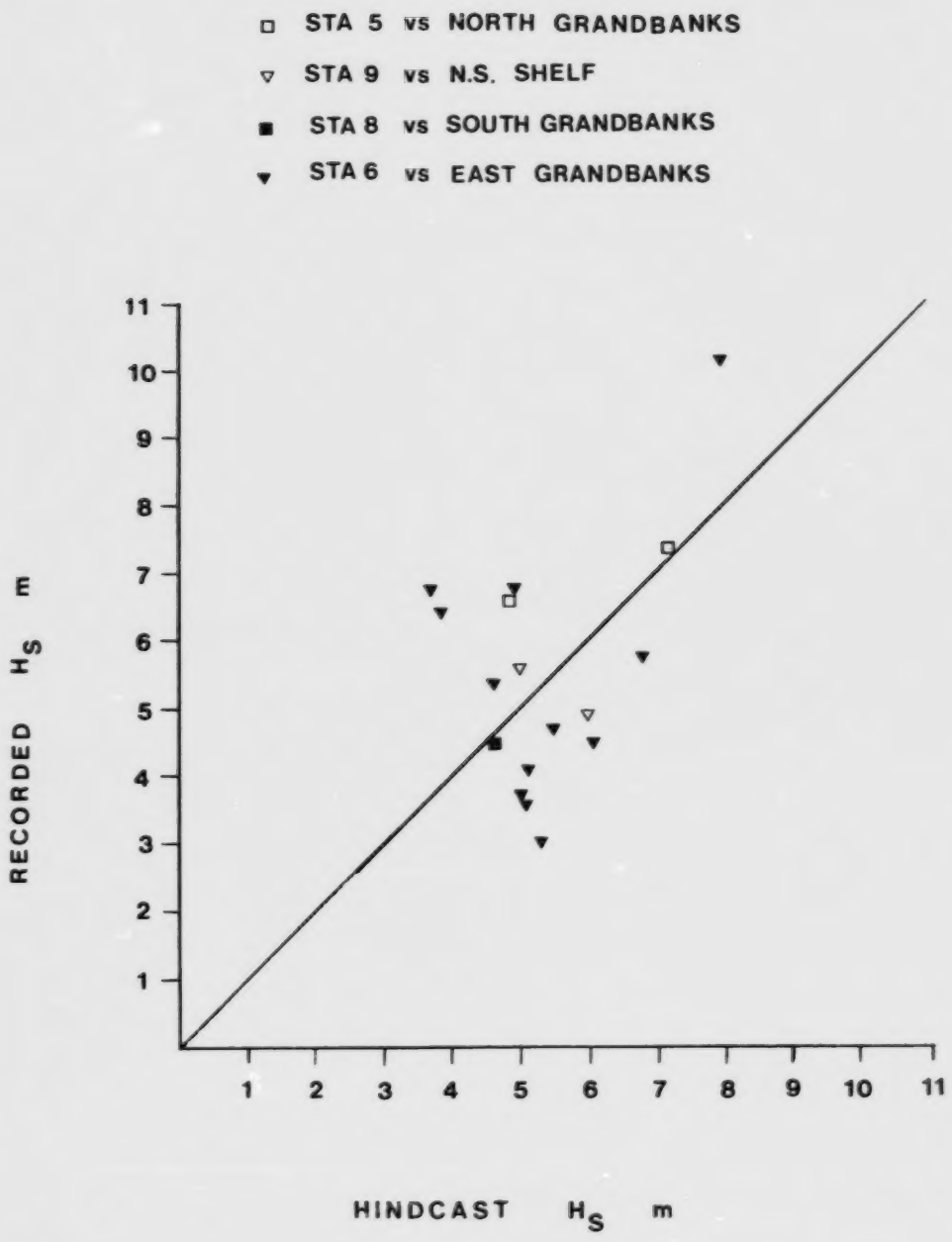

□ STA 5 vs NORTH GRANDBANKS
▽ STA 9 vs N.S. SHELF
■ STA 8 vs SOUTH GRANDBANKS
▼ STA 6 vs EAST GRANDBANKS
RECORDED H_S m
HINDCAST H_S m
1
2
3
4
5
6
7
8
9
10
11

Figure 3

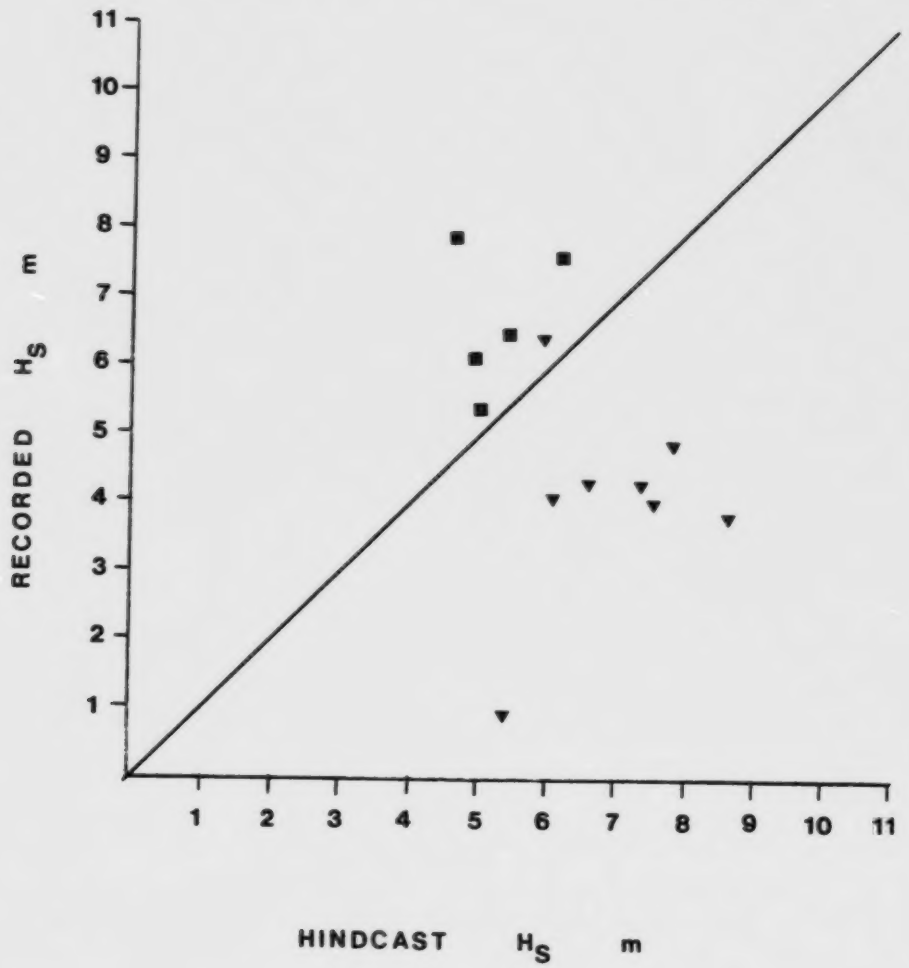


Figure 4

5 DISCUSSION

Differences between the hindcast and recorded wave data may occur for the following reasons:

(i) There is a significant distance between the hindcast grid points and the wave recorder locations. Only in the comparisons between grid point 5 and station 94 (July, August, September, October 1974 and June, July, August 1975) and grid point 9 and stations 91(7) and 90(7) (July 1974, January 1975) was there a reasonable distance (82 km, 115 km, 90 km respectively) between the two points. For the other comparisons the distance varied from 146 km to 380 km (except for stations close to Sable Island).

(ii) The recorded wave data are influenced by the adjacent shoreline or by shallow water which was not considered in the wave hindcast. The comparisons between grid point 10 and stations 90(4) and 91(5) (March and April 1974) close to Sable Island clearly illustrate this problem.

(iii) The overwater wind field was inadequately defined for use in the hindcast. It is not possible to properly assess this question as the wind velocities used in the hindcast were not available. Synoptic weather maps were reviewed during the course of this study. For some storms the recorded wave data appeared to be compatible with the wind velocity and isobars shown on the synoptic maps while the hindcast wave data either overestimated or underestimated the recorded wave data. Examples are: Sept 4 & 6, 1973, 6 vs 93(1); Oct 1, 1973, 6A vs 93(2); Dec 1973, 9 vs 91(3); Feb 25, 26, 1974, 10 vs 91(4); Sept 28, 1974, 5 vs 94; Aug 24, 1975, 5 vs 90(9)). However, a conclusion cannot be made without comparing the windspeed used in the hindcast with wind speeds recorded at the drill ships or wind speeds estimated from the isobar configuration or pressure gradients.

(iv) The grid distance was too large to correctly define the distribution of wind velocity in small intense low pressure disturbances, such as hurricanes or tropical storms.

Waves generated by hurricanes were not recorded during the period of this comparison. The tropical storm Gilda did pass into the area on October 28, 1973. However, at this time the storm had reached the extratropical stage and should have been well defined by the hindcast grid. In general, it is considered that the hindcast grid was adequate to define all storms except for hurricanes and tropical storms.

(v) The hindcast model does not correctly represent the real wind-wave generation process. It is not possible to assess this question during this study.

6 CONCLUSIONS

(i) the comparison contained in the report does not provide a definitive assessment of the hindcast wave data.

(ii) The archived hindcast wave data do not provide an accurate description of the sea state on the Grand Banks and Nova Scotian shelf at any given hour. Because exact comparisons of the hindcast and recorded data over these areas are not available it is not possible to determine whether or not the hindcast wave data represent the wave climate of the Grand Banks or Nova Scotian shelf. However, the hindcast data may provide an accurate representation of the wave climate of the grid point locations which are to the south and east of the Grand Banks and Nova Scotian shelf and are shown in Figure 1.

(iii) Definition of the wave climate of locations on the Grand Banks, Nova Scotian shelf and Labrador Sea may require repeating the hindcast analysis and saving the resulting data at additional grid points, over the Grand Banks, Nova Scotian Shelf, and Labrador Sea, including an analysis of the effects of shallow water. Consideration should also be given to repeating the hindcast with a smaller grid, with a more accurate representation of the shoreline, and with an improved description of the wind field. Further studies, discussed in section 7, are required to assess whether or not the hindcast should be repeated.

7 RECOMMENDATIONS

(i) Frequency of occurrence analyses should be undertaken of all the archived hindcast wave data in the vicinity of the Labrador Sea, Grand Banks and Nova Scotian shelf. The hindcast locations that are in shallow water, particularly location 10 close to Sable Island, should be excluded. This analysis will demonstrate the spacial variation in the wave climate and, therefore, the need to archive data at additional grid points in any future analysis.

(ii) An assessment should be undertaken of the effects of shallow water on the wave climate at a number of representative locations in the Labrador Sea, Grand Banks, and Nova Scotian shelf. The assessment will describe the importance of considering shallow water effects in future analyses.

(iii) A comparison should be undertaken of the wind used in the hindcast analysis with recorded winds or wind velocities estimated from synoptic weather maps.

(iv) Following completion of (i), (ii) and (iii) and depending on the conclusions, the hindcast study should be repeated. This second hindcast may have the following characteristics:

- improved definition of the wind field over the area of interest during storms.

- smaller grid and more accurately defined shoreline than in previous hindcast

- data archived for a greater number of locations in deep water

- shallow water effects included in the analysis for some locations

- hindcast undertaken for all periods when recorded wave data are available for comparison (including 1976 to 1980)

(v) A wind wave hindcast should be undertaken, conditional on the results of (iv), to fully define the wave climate of the Labrador Sea, Grand Banks, and Nova Scotian shelf.

8 REFERENCES

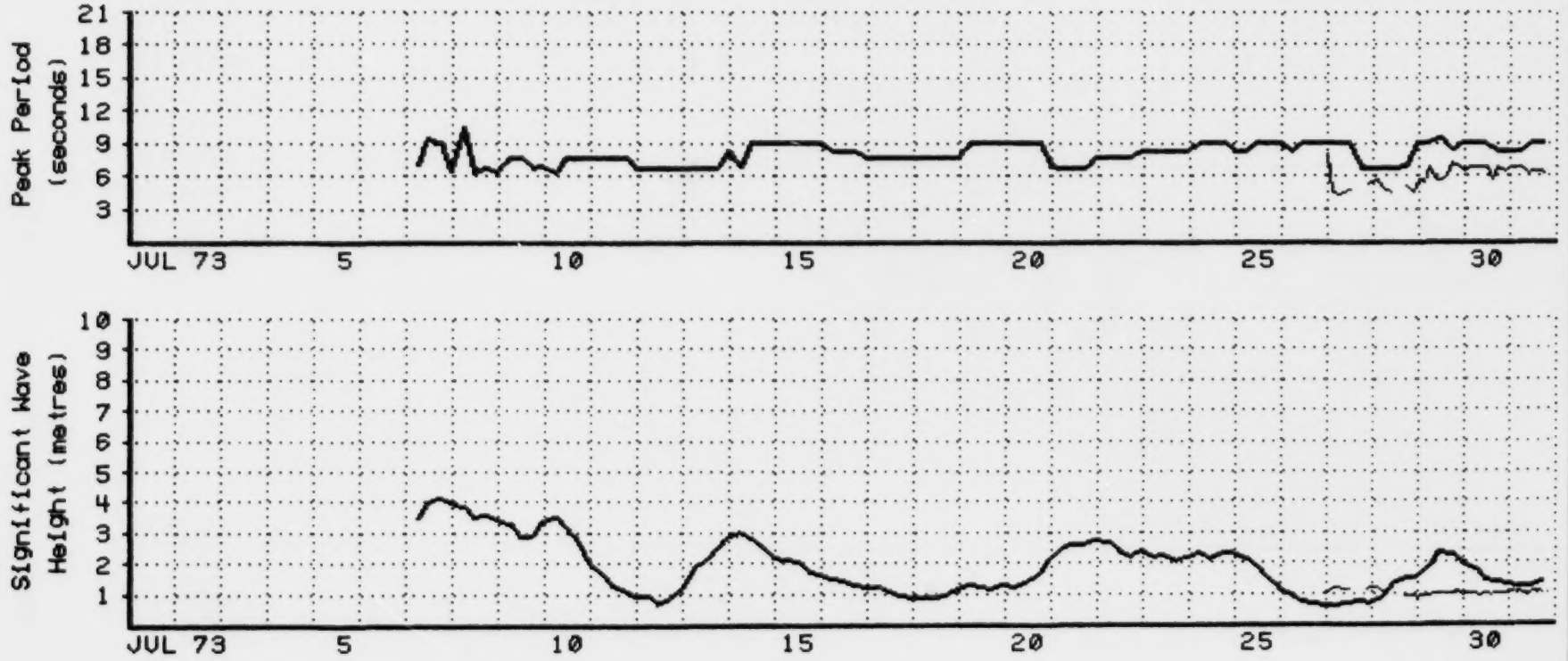
Lazanoff, S. M. and Stevenson, N. M. A twenty Year Northern Hemisphere Wave Spectral Climatology. Proceedings of the NATO Conference on Turbulent Fluxes through the Sea Surface, Wave Dynamics and Prediction. France 1977.

Vincent, C. L. , and Resio, D. T. A Discussion of Wave Prediction in the Northwest Atlantic Ocean. International Liege Colloquium on Ocean Hydrodynamics, Belgium, 1979.

APPENDIX A

PLOTS OF HINDCAST AND RECORDED WAVE DATA VERSUS TIME

GFC



Hindcast Wave File: W+SI.BAIRD.6

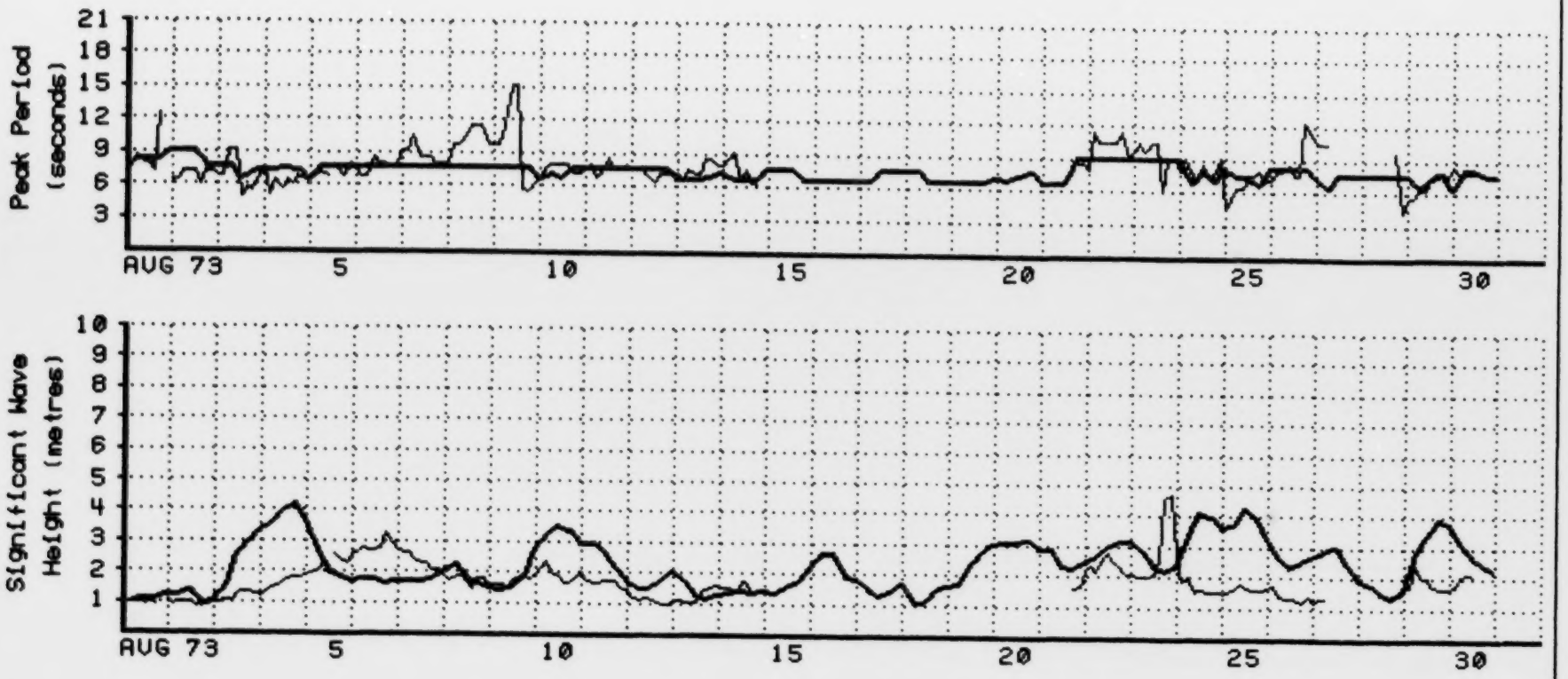
Recorded Wave File: W+MEDS.REC.92.GMT

Comment ..... : SEDNET H 92

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



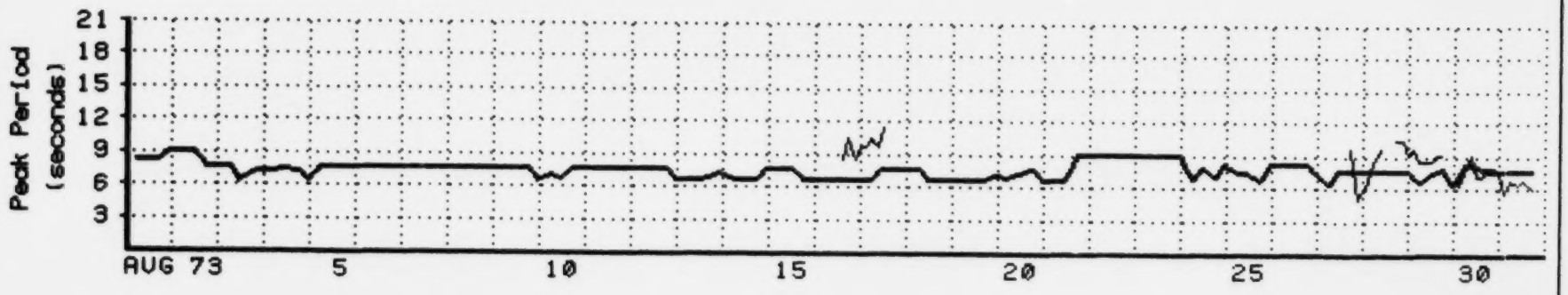
Hindcast Wave File: W+SI.BAIRD.6

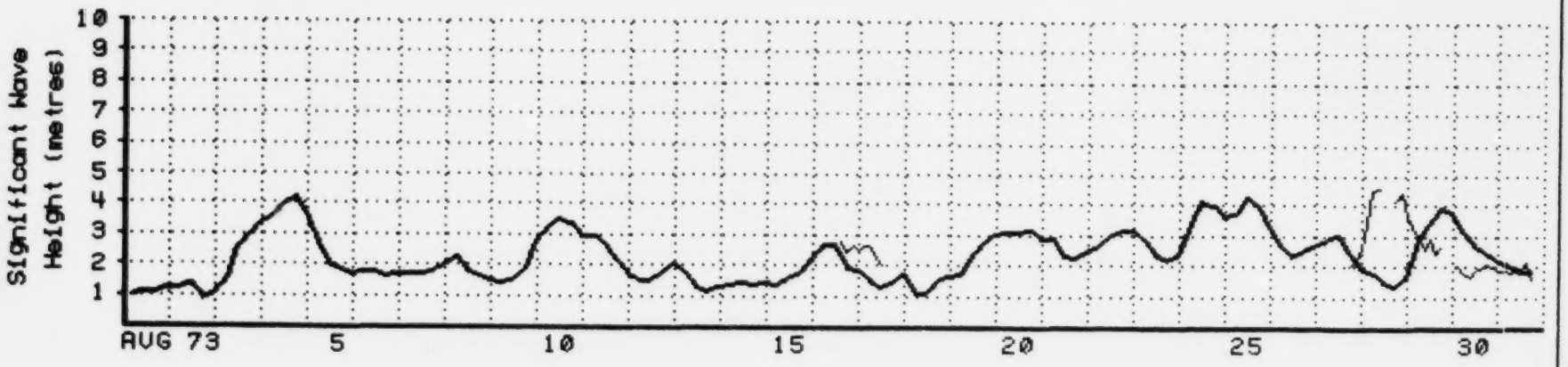
Recorded Wave File: W+MEDS.REC.92.GMT

Comment ..... : SEDNET H 92

LEGEND: — hindcast — recorded

GFC





Hindcast Wave File: W+SI.BAIRD.6

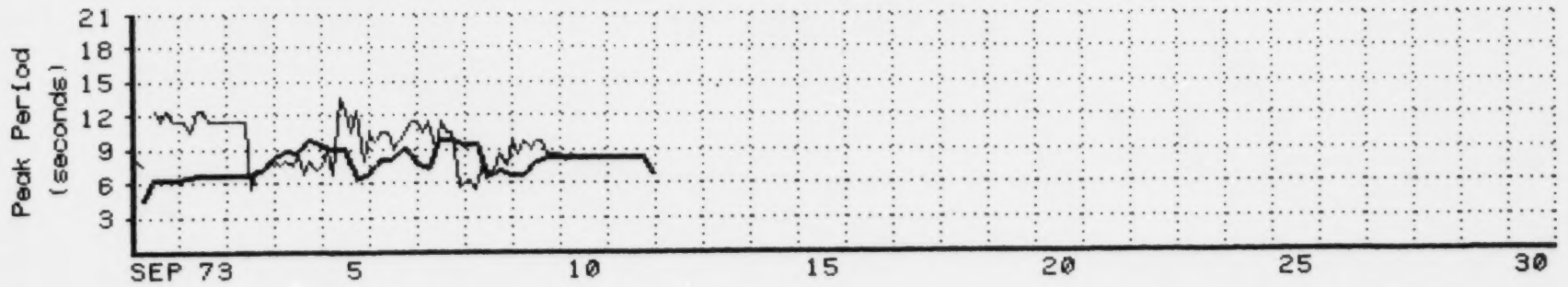
Recorded Wave File: W+MEDS.REC.93.GMT

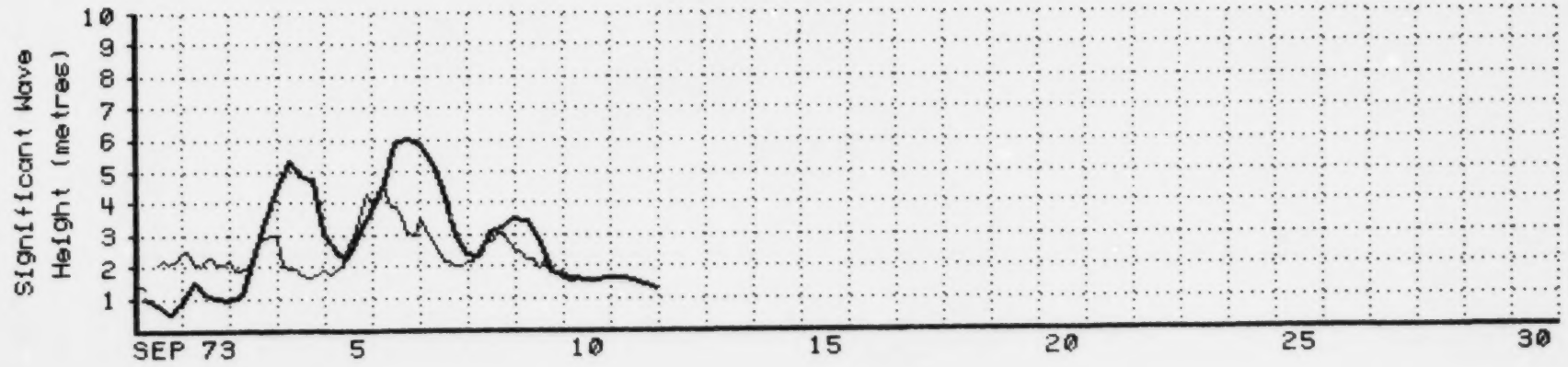
Comment ..... : SEDCO I 93(1)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W+SI.BAIRD.6

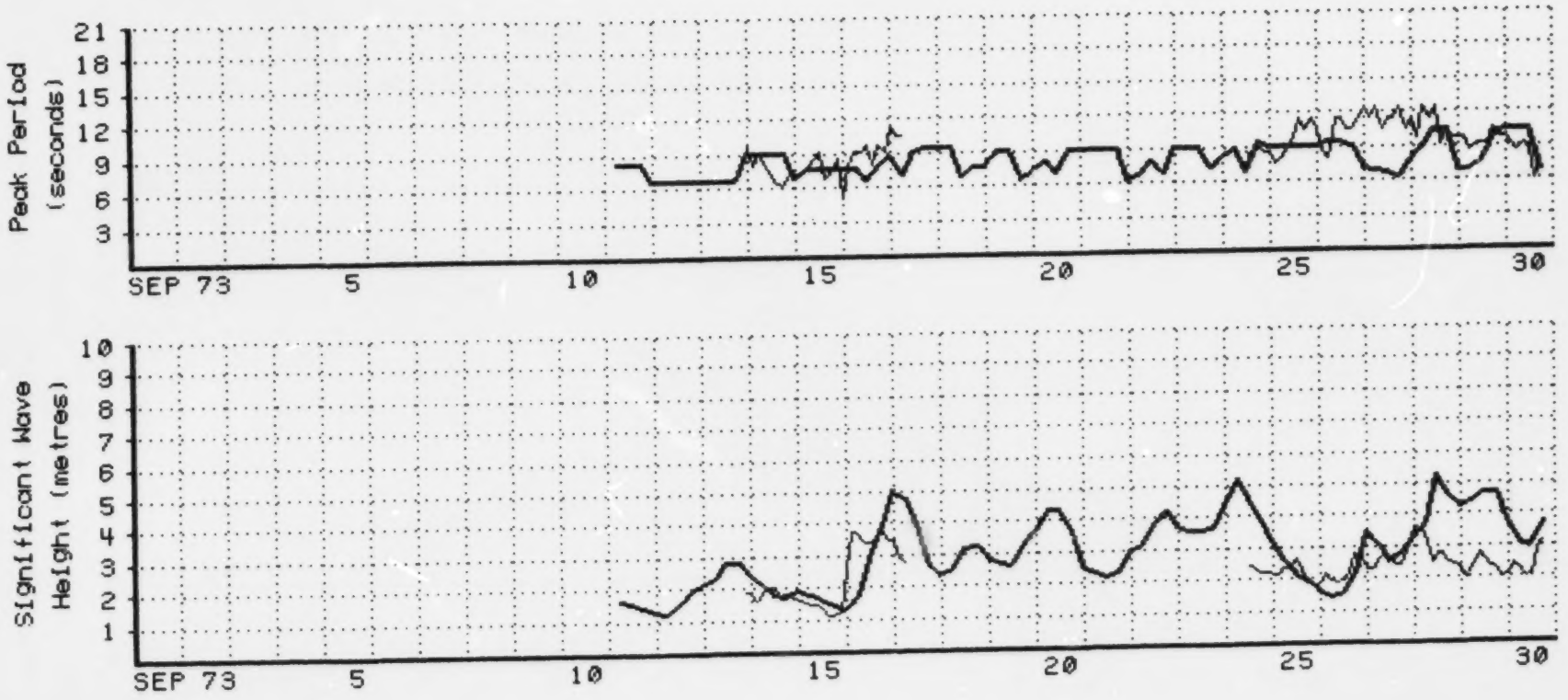
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(1)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.6

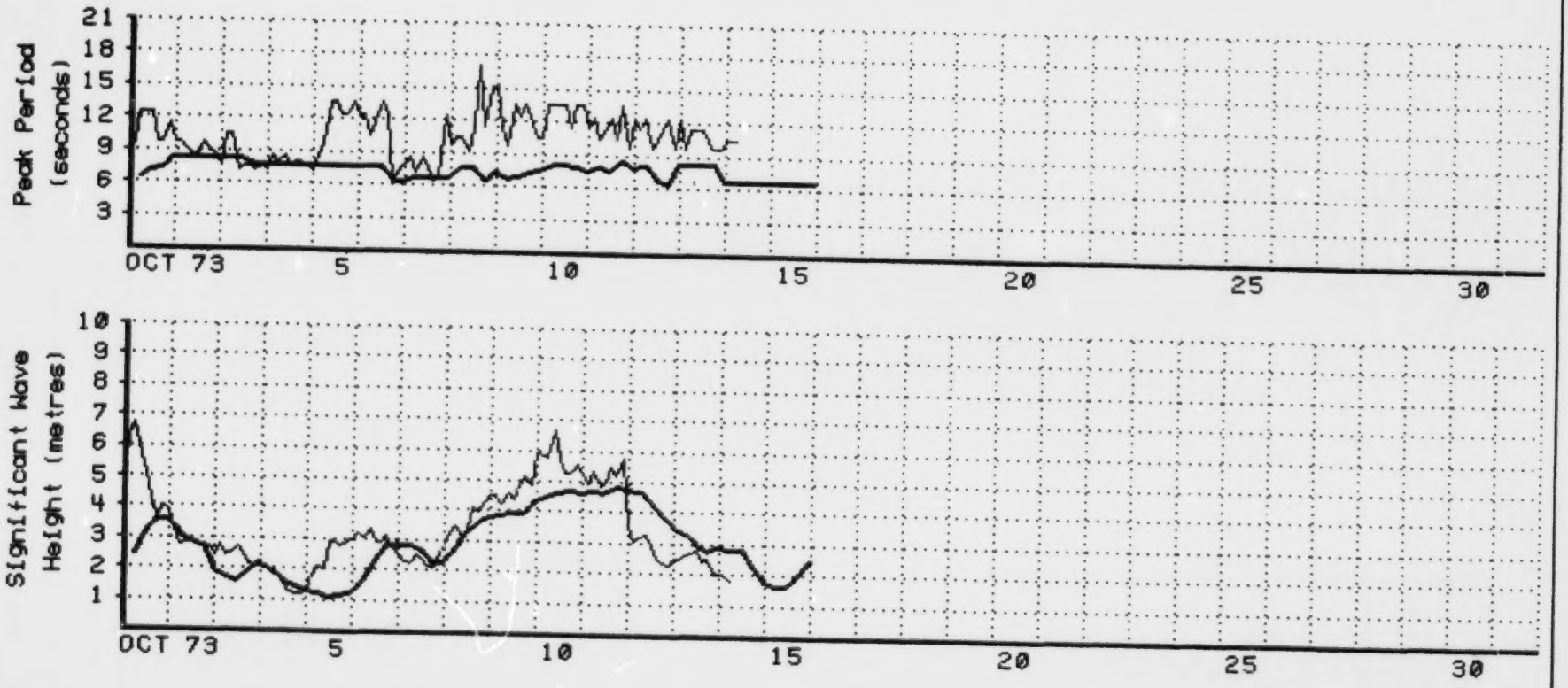
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(2)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.6A

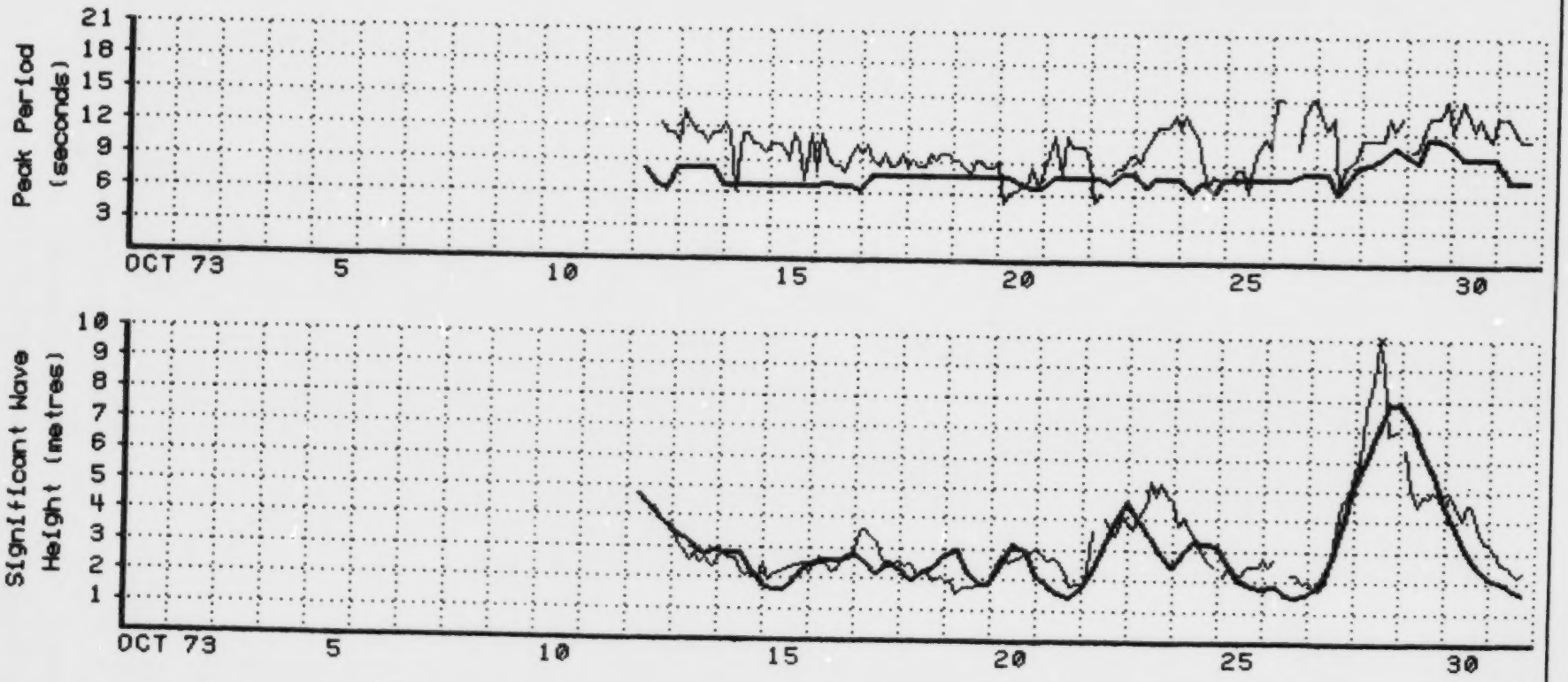
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(2)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.6A

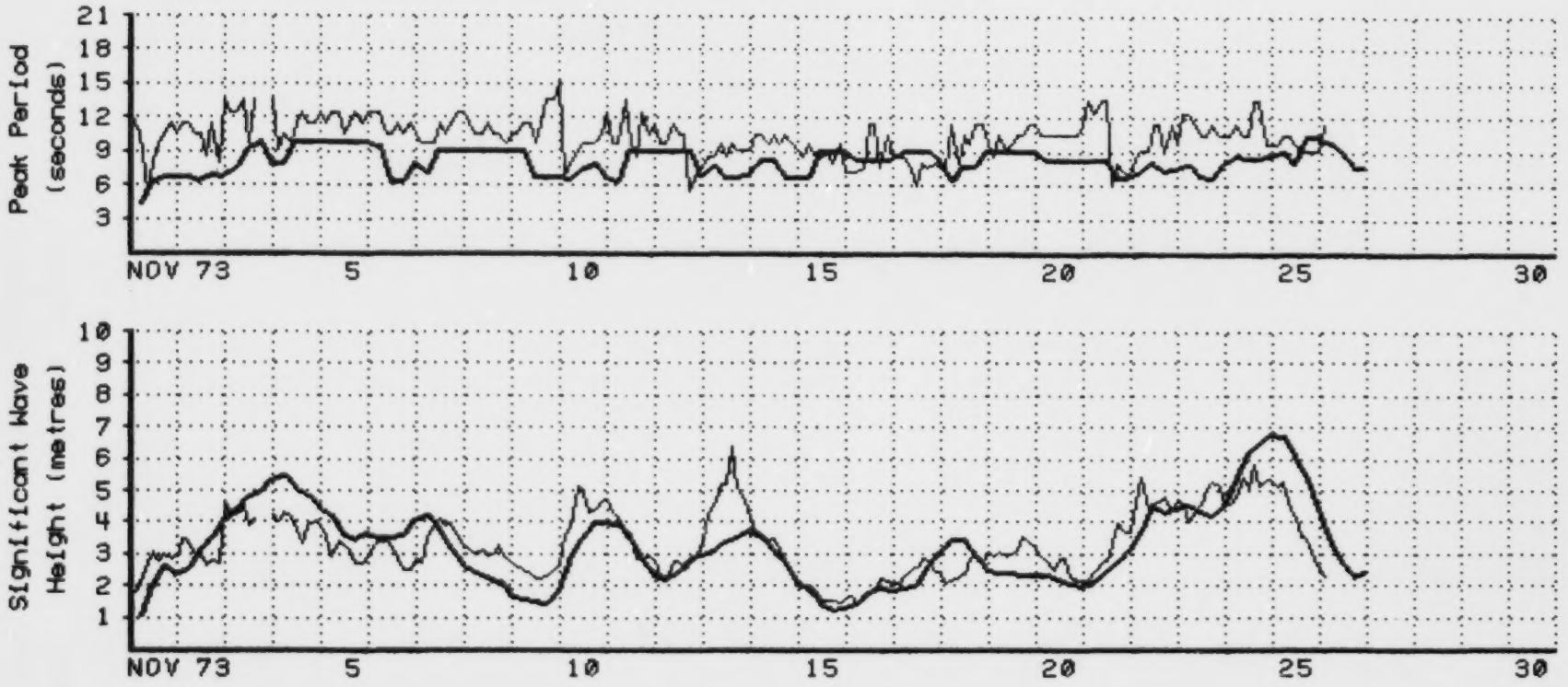
Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(2)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.6A

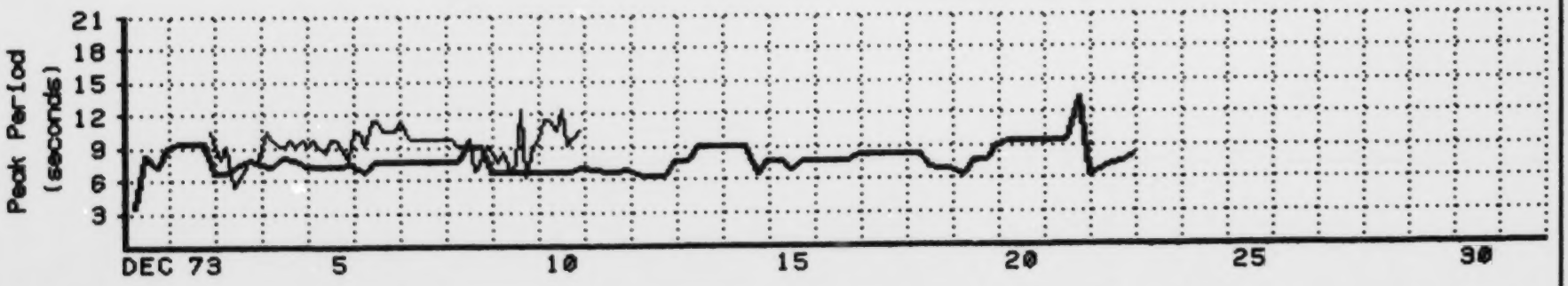
Recorded Wave File: W+MEDS.REC.90.GMT

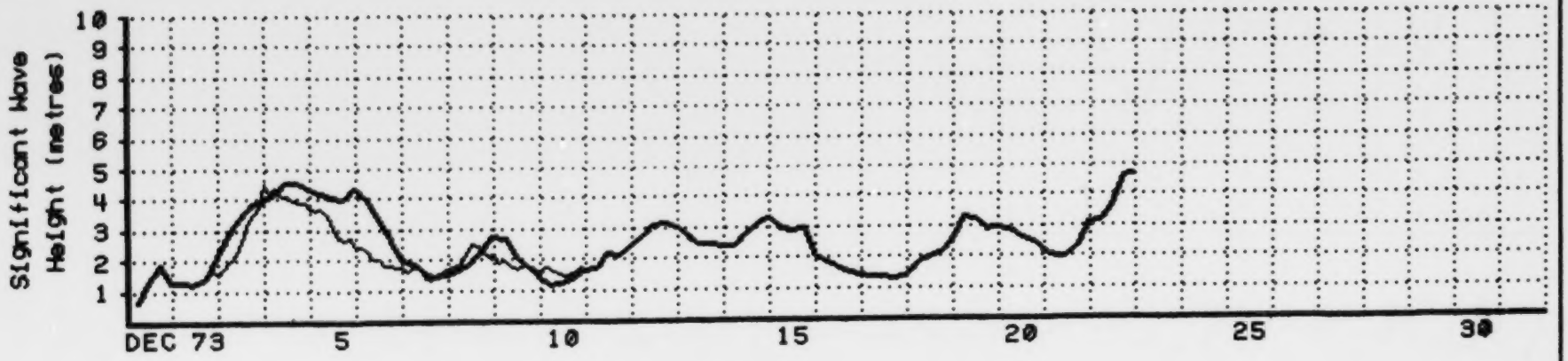
Comment ..... : SEDCO J 90(2)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W+SI.BAIRD.8A

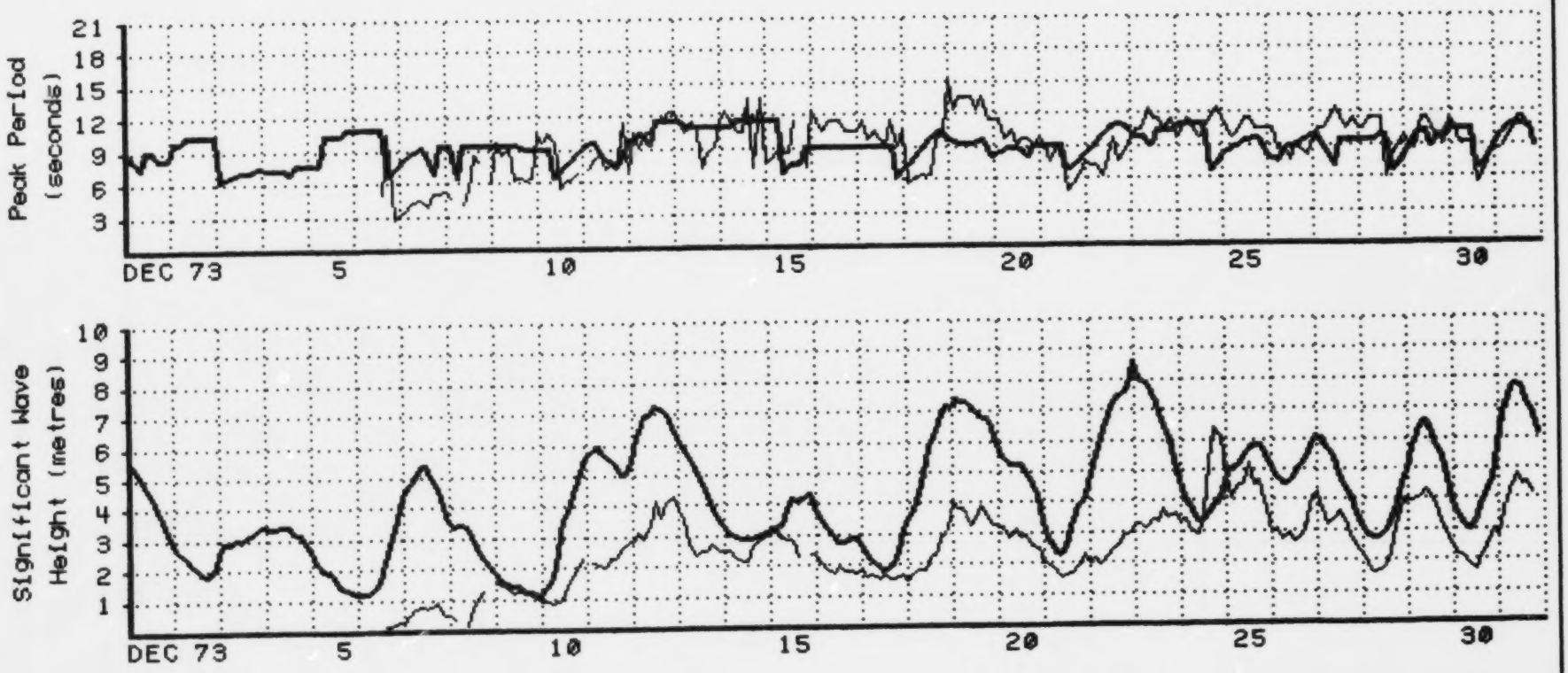
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(4)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.9

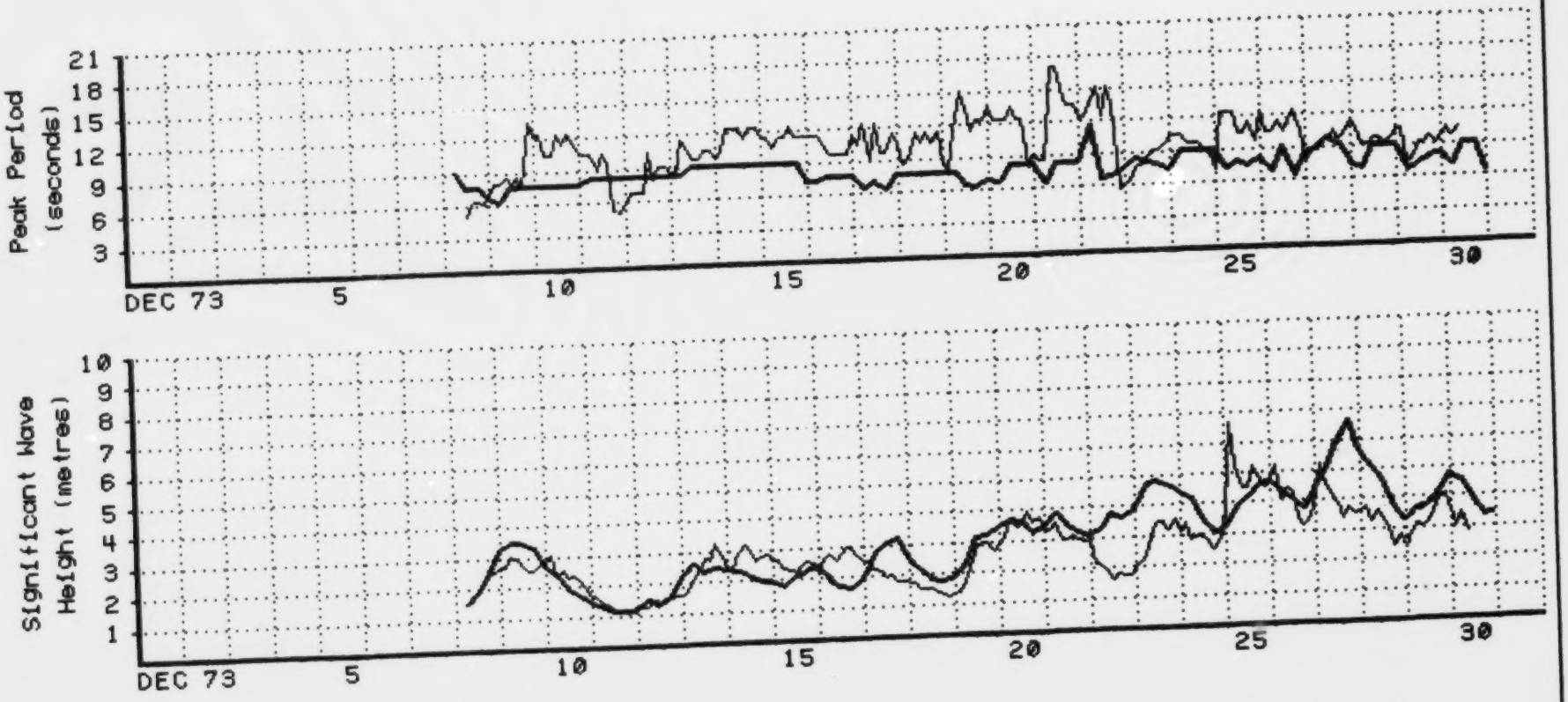
Recorded Wave File: W+MEDS.REC.91.GMT

Comment ..... : SEDCO H 91(3)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.6A

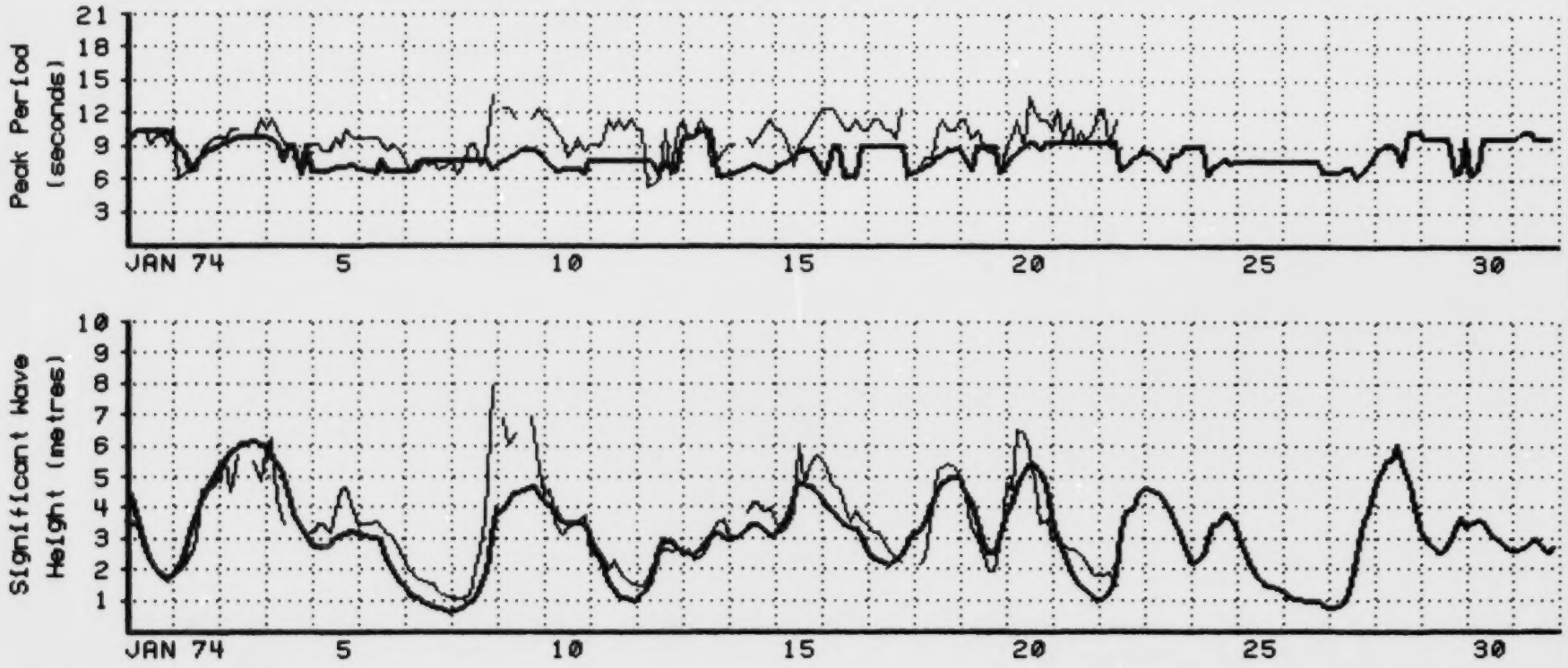
Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(3)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.9

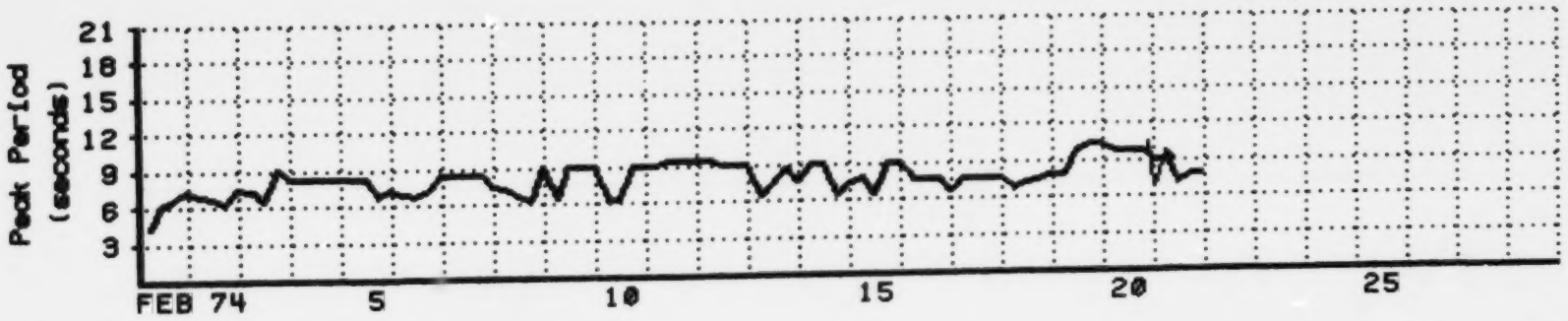
Recorded Wave File: W+MEDS.REC.91.GMT

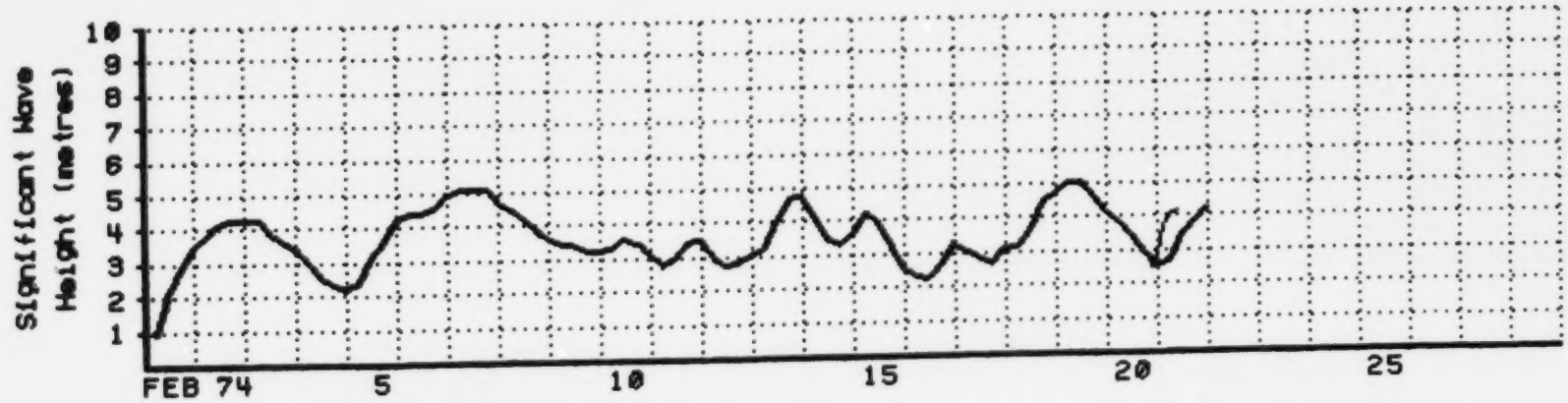
Comment ..... : SEDCO H 91(3)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W+SI.BAIRD.6A

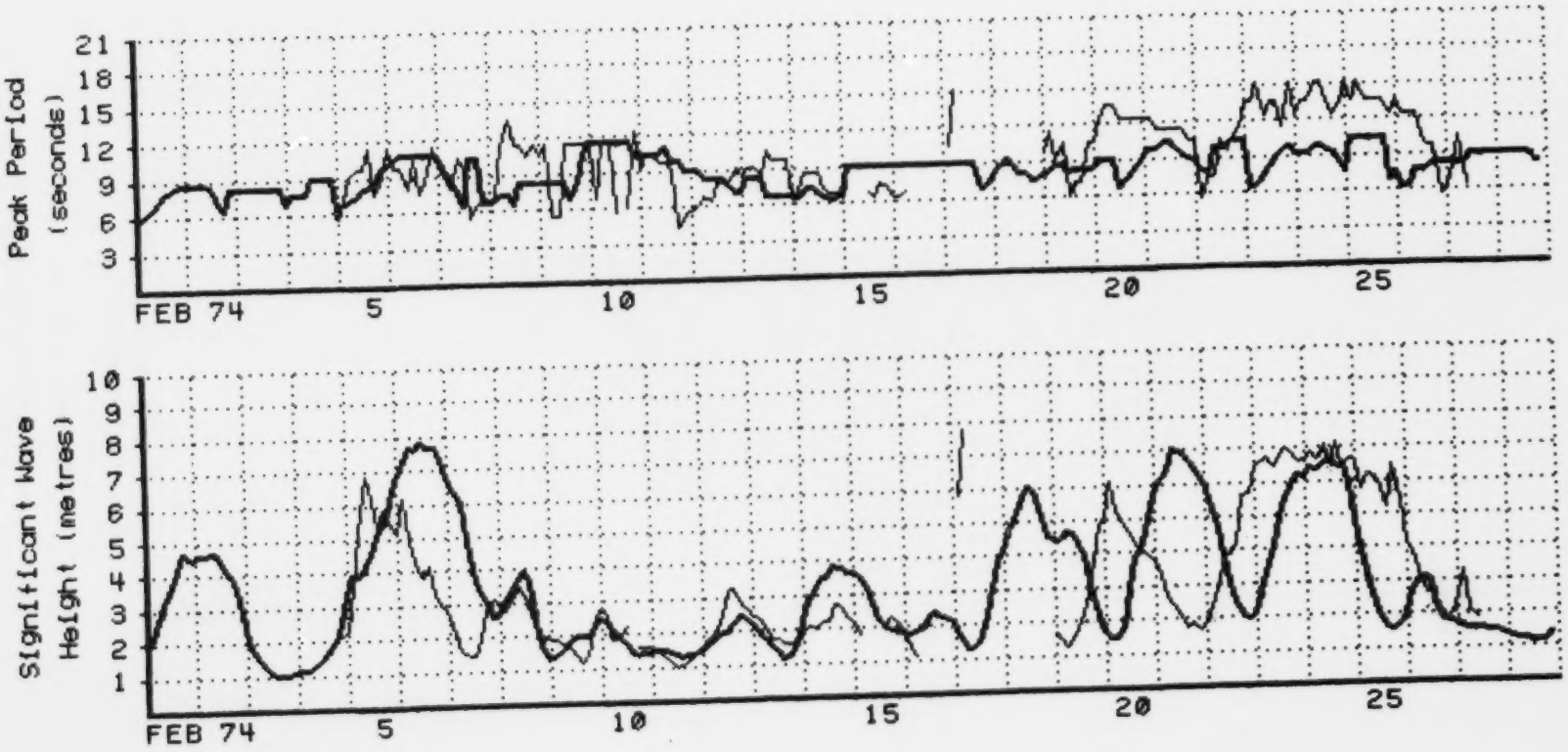
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(5)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W←SI.BAIRD.10

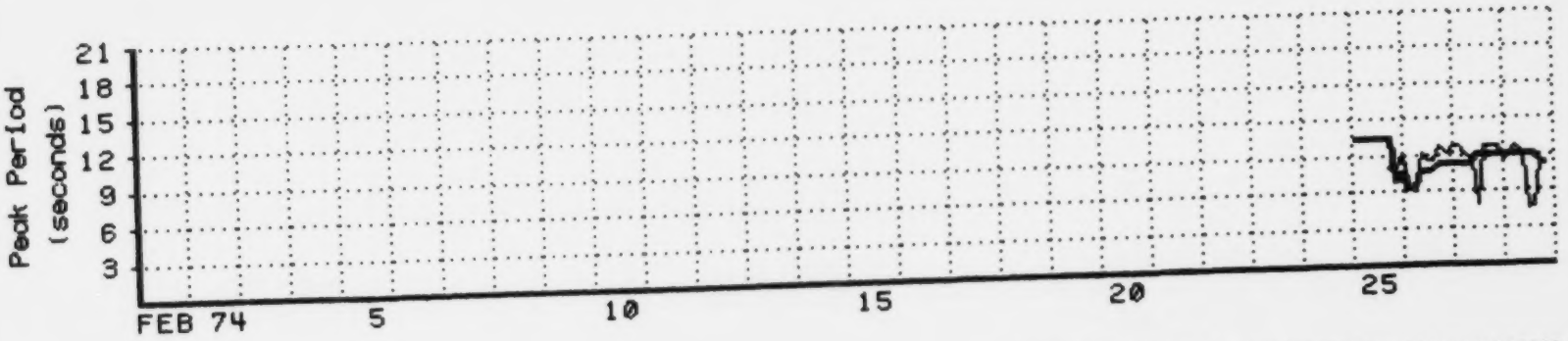
Recorded Wave File: W←MEDS.REC.91.GMT

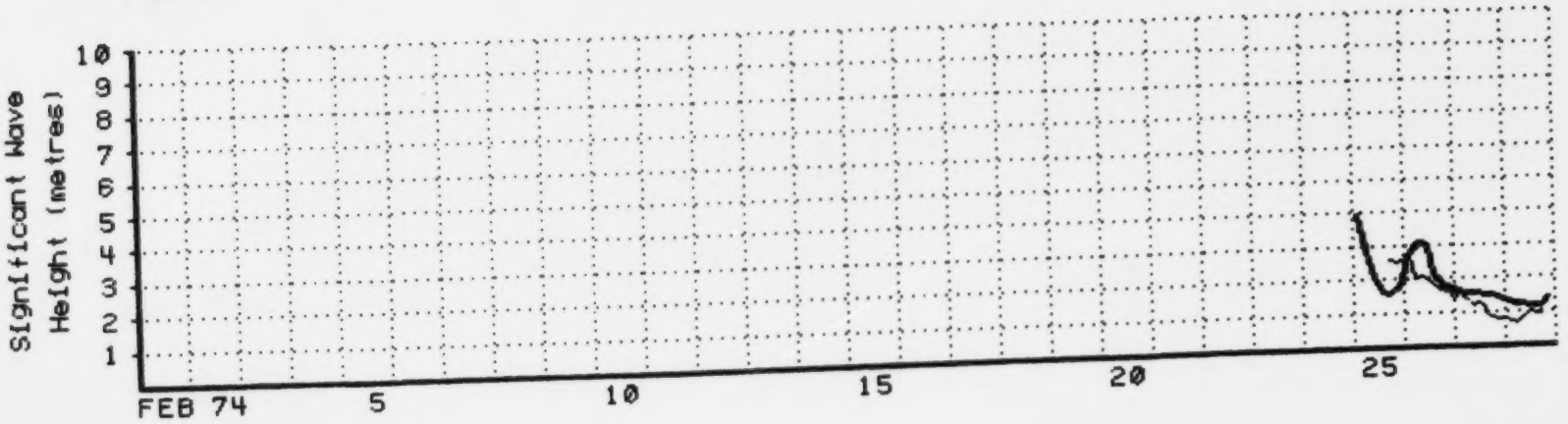
Comment ..... : SEDCO H 91(4)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W-SI.BAIRD.10

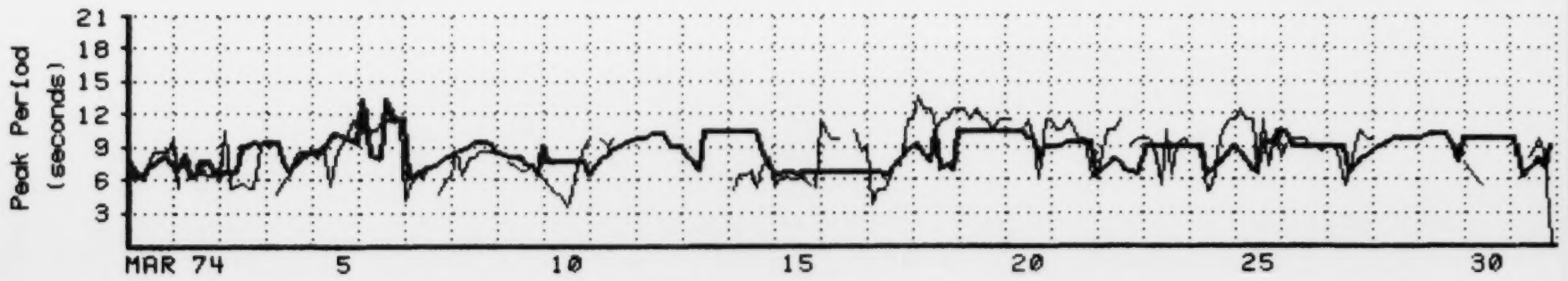
Recorded Wave File: W-MEDS.REC.90.GMT

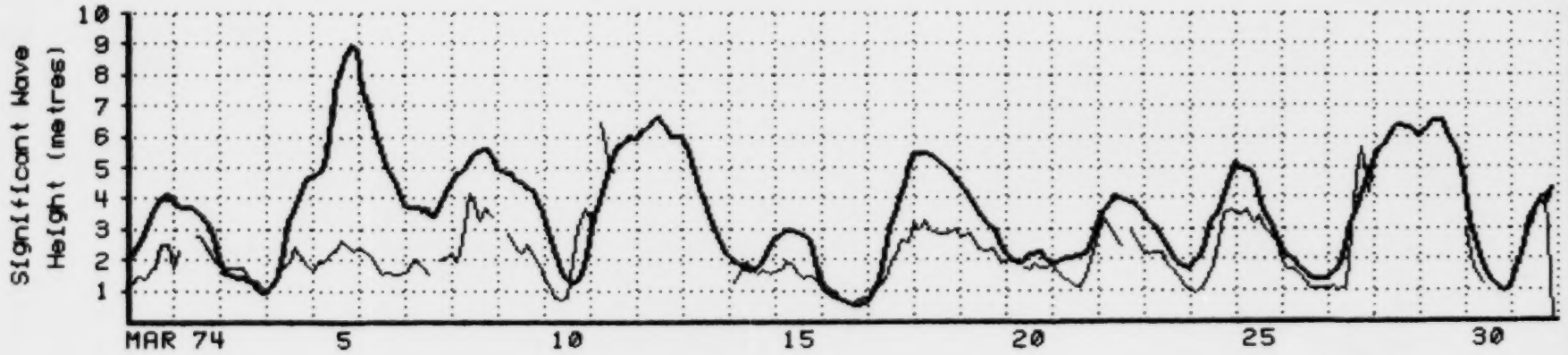
Comment ..... : SEDCO J 90(4)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W←SI.BAIRD.10

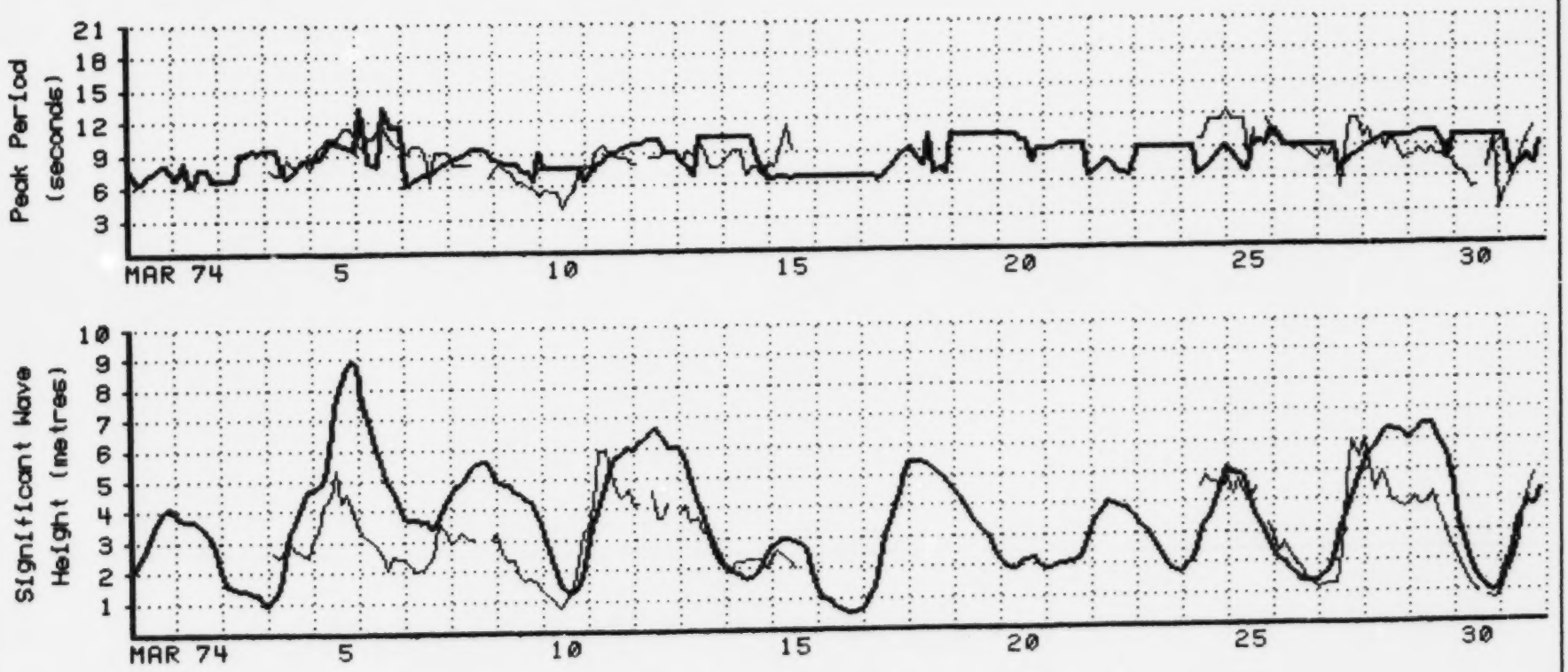
Recorded Wave File: W←MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(4)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.10

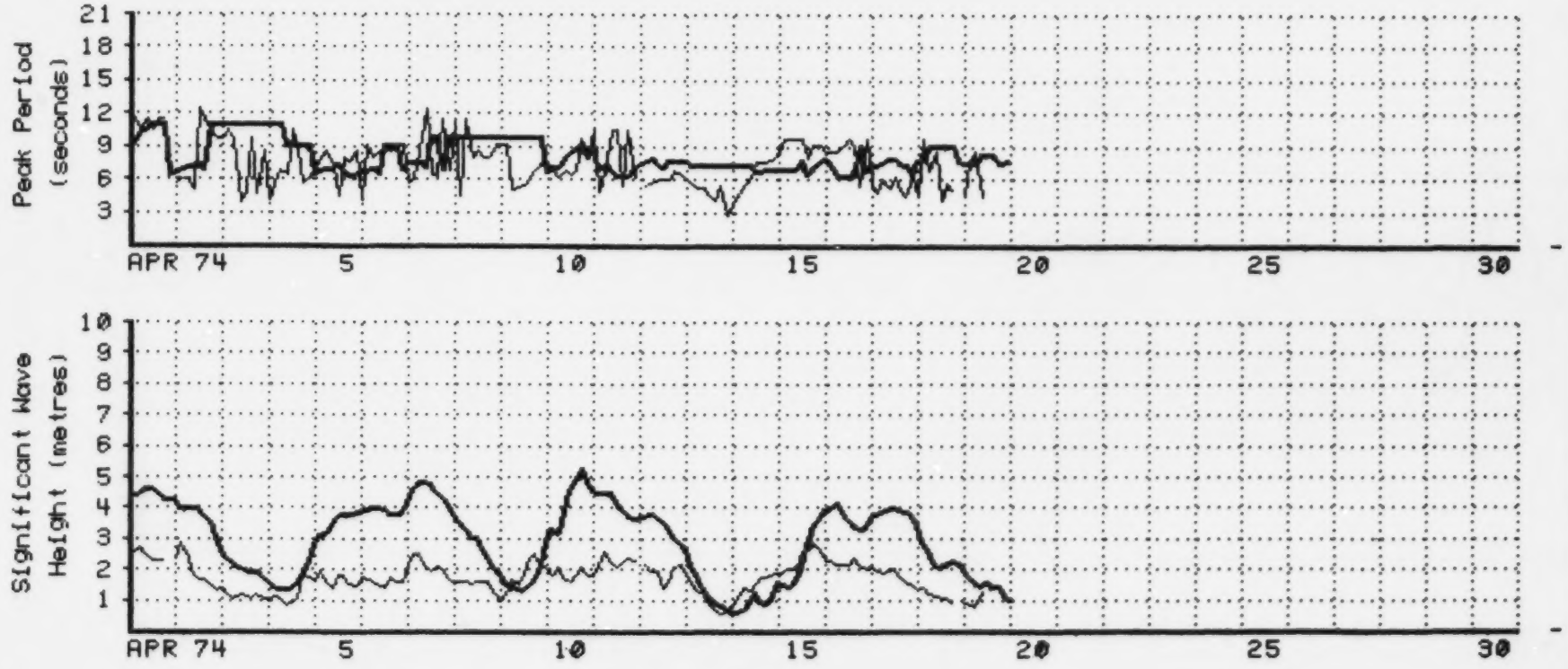
Recorded Wave File: W+MEDS.REC.91.GMT

Comment ..... : SEDCO H 91(5)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.10

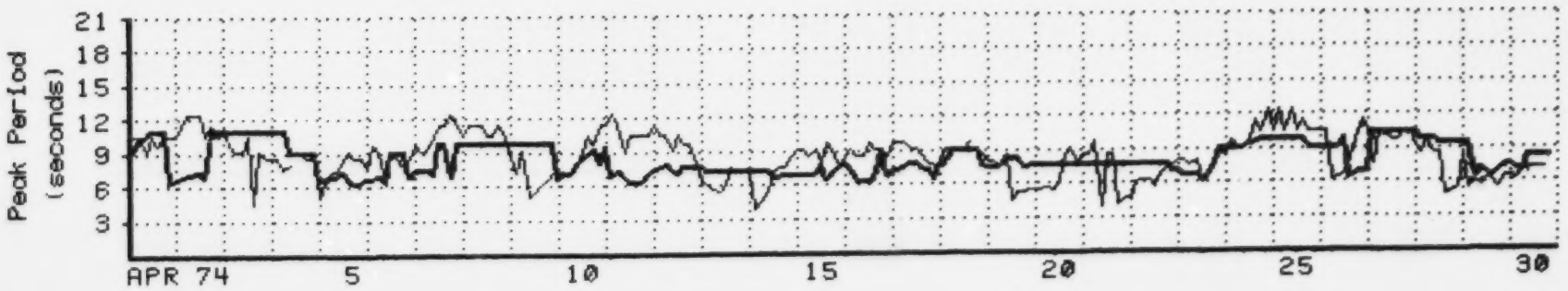
Recorded Wave File: W+MEDS.REC.90.GMT

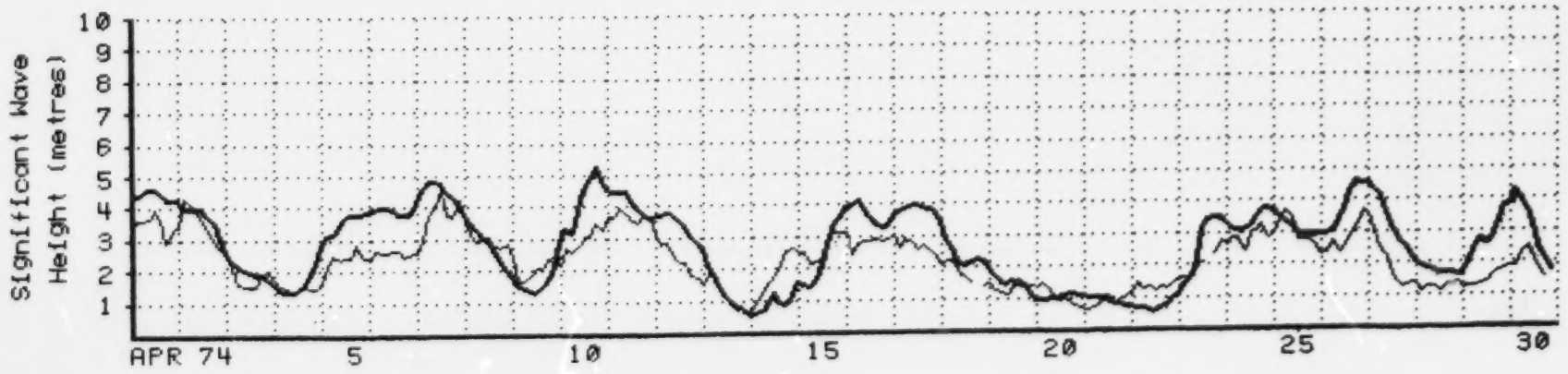
Comment ..... : SEDCO J 90(4)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W+SI.BAIRD.10

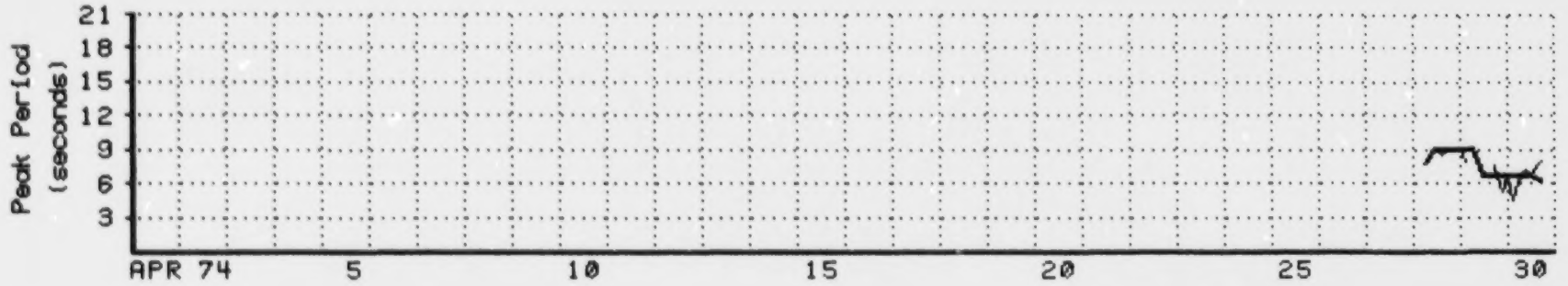
Recorded Wave File: W+MEDS.REC.91.GMT

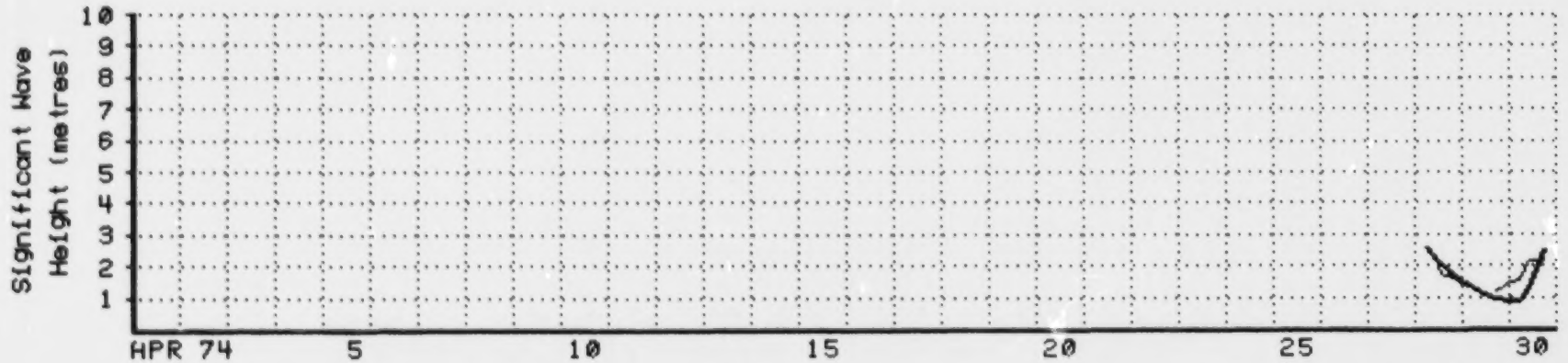
Comment ..... : SEDCO H 91(5)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W+SI.BAIRD.8

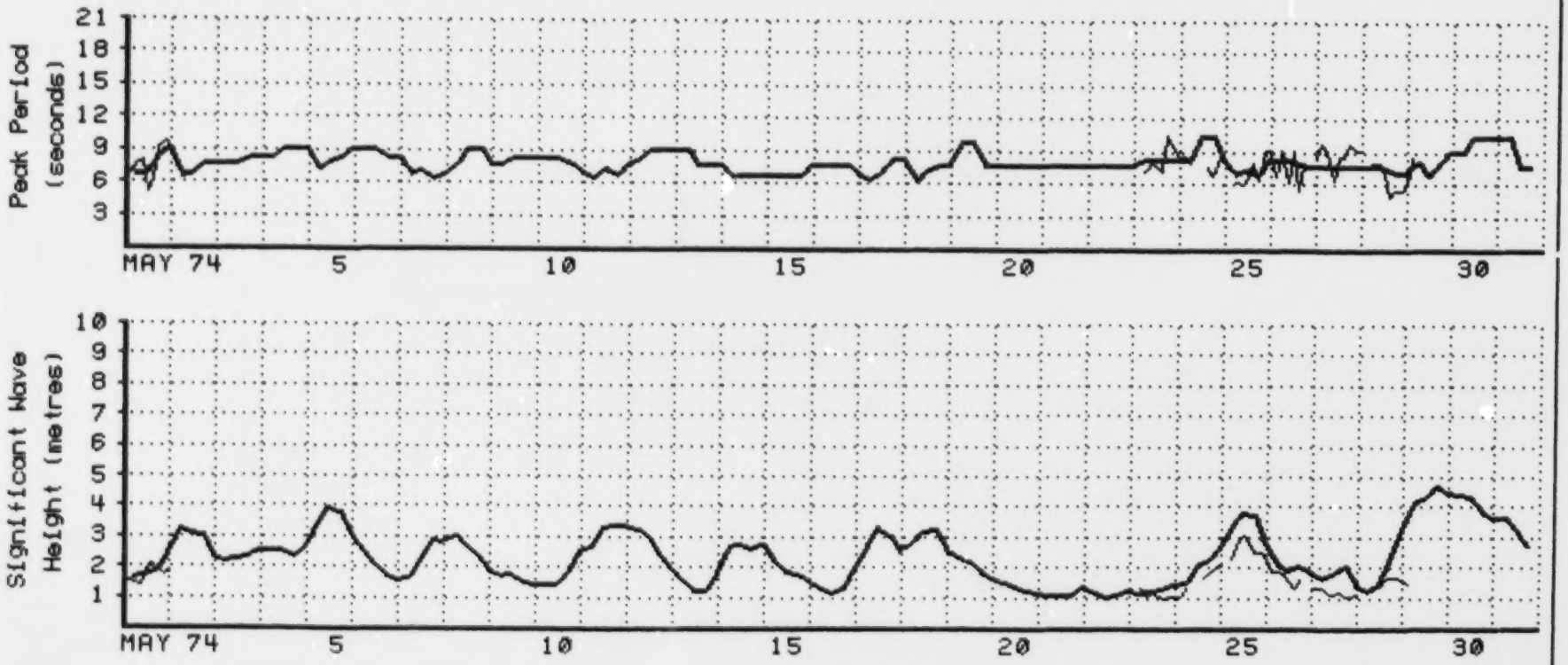
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(6)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.8

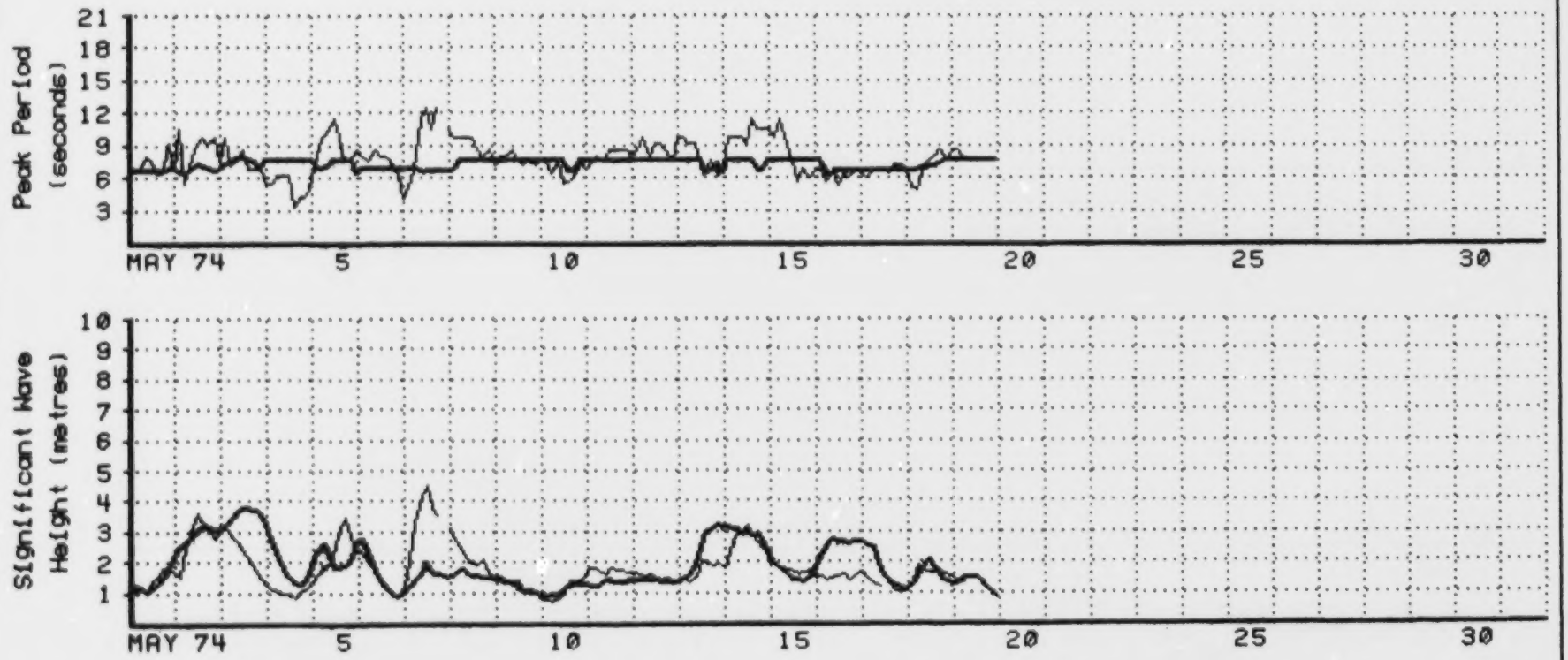
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(6)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.10

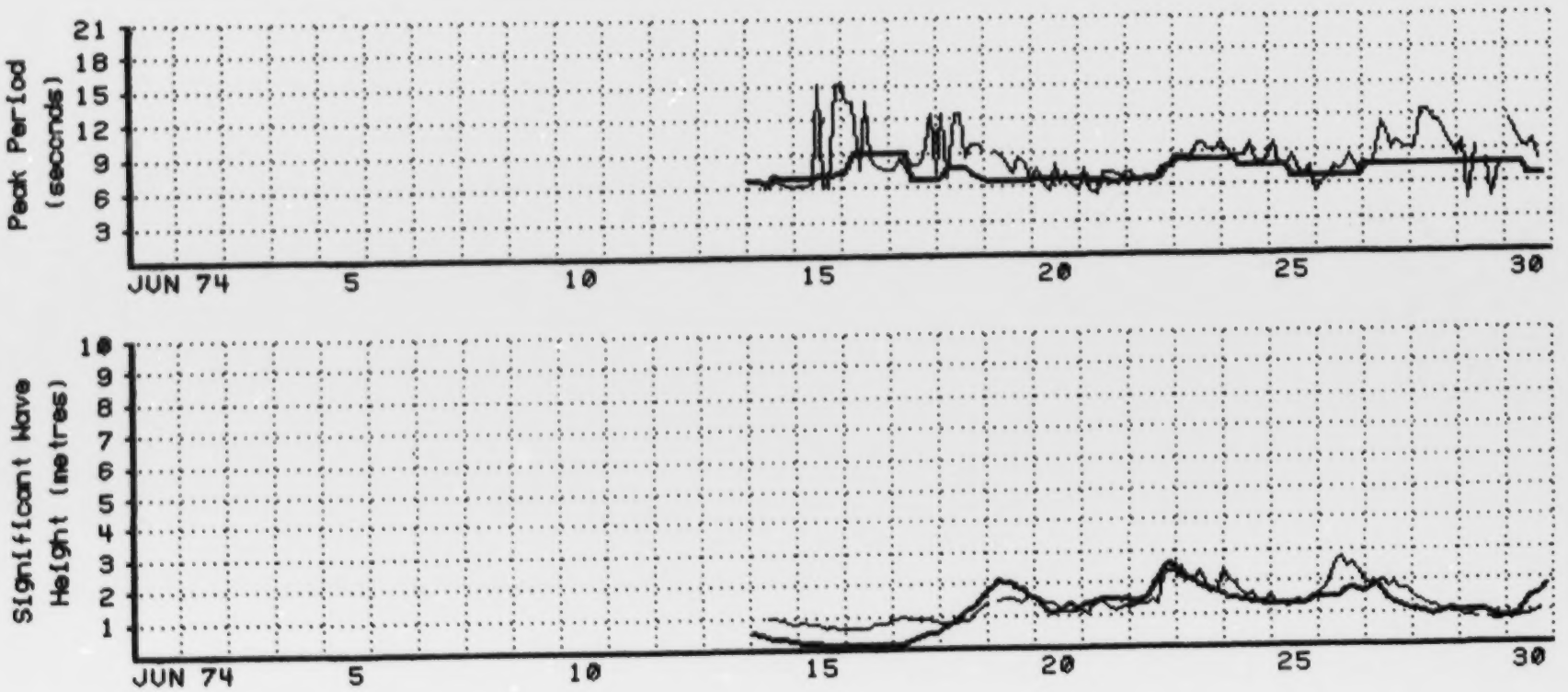
Recorded Wave File: W+MEDS.REC.91.GMT

Comment ..... : SEDCO H 91(5)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.10

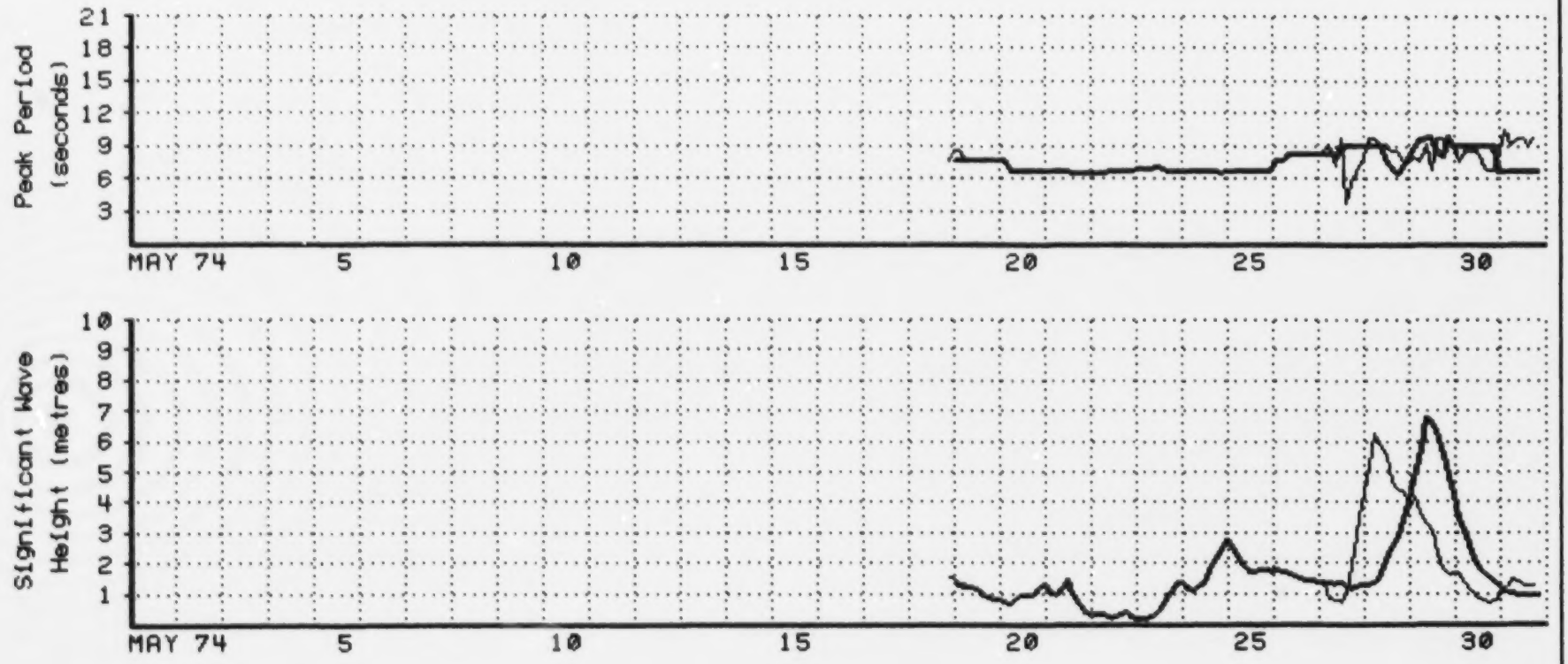
Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(5)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.12

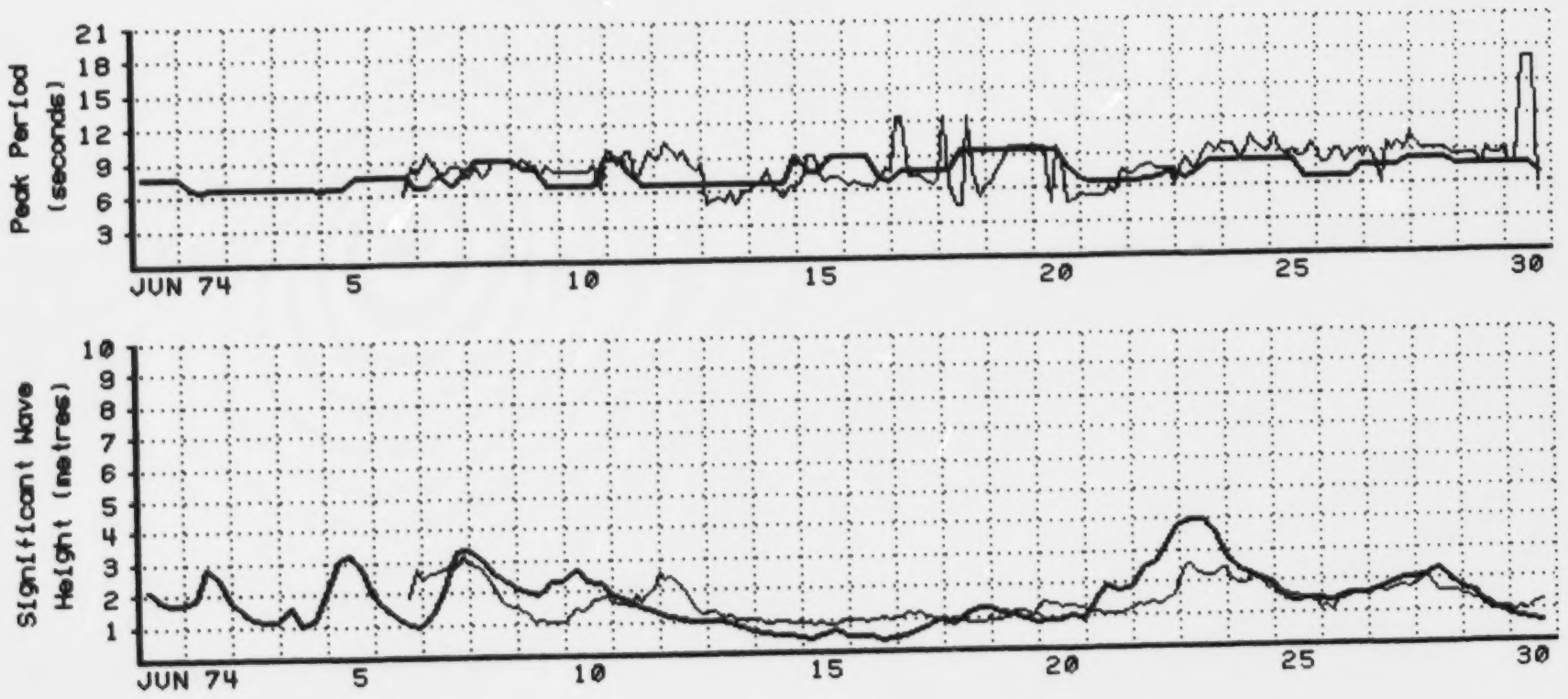
Recorded Wave File: W+MEDS.REC.91.GMT

Comment ..... : SEDCO H 91(6)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.8

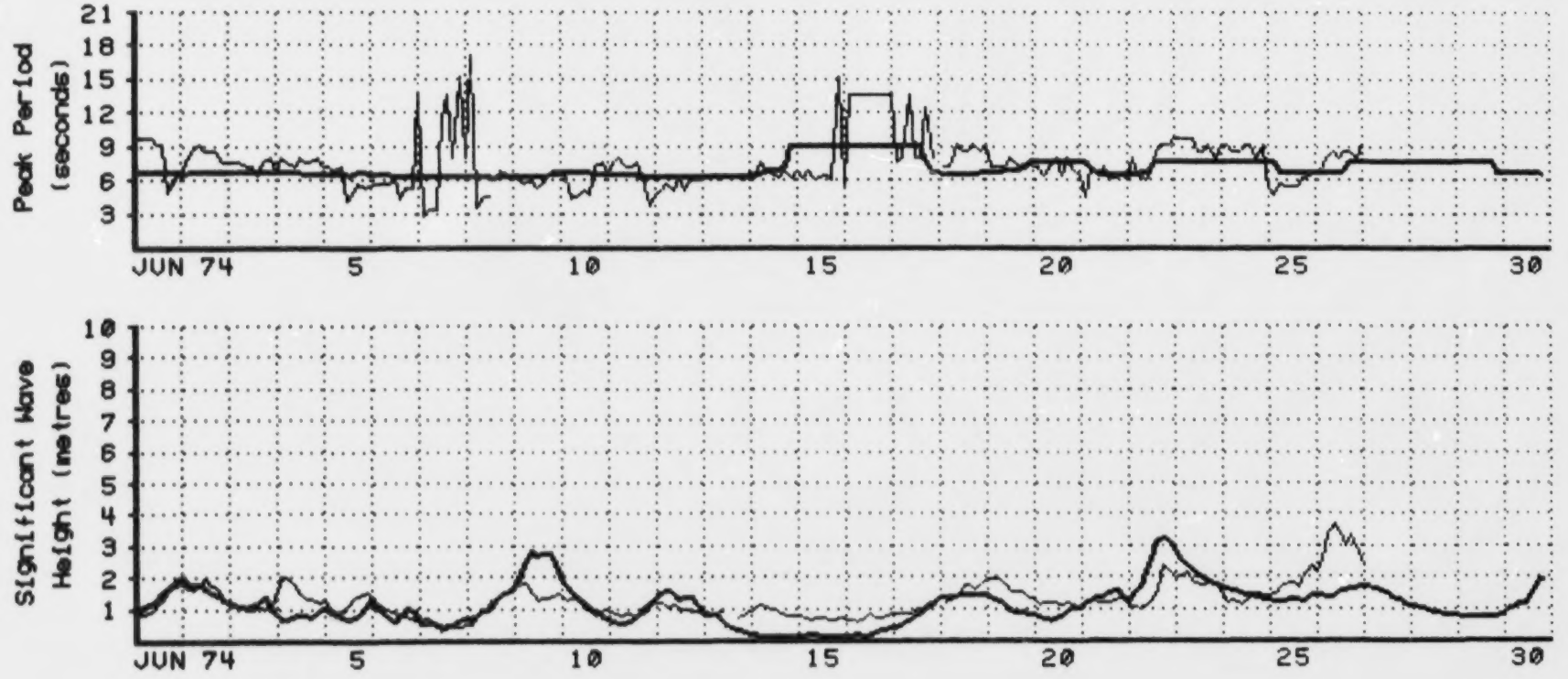
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(6)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.12

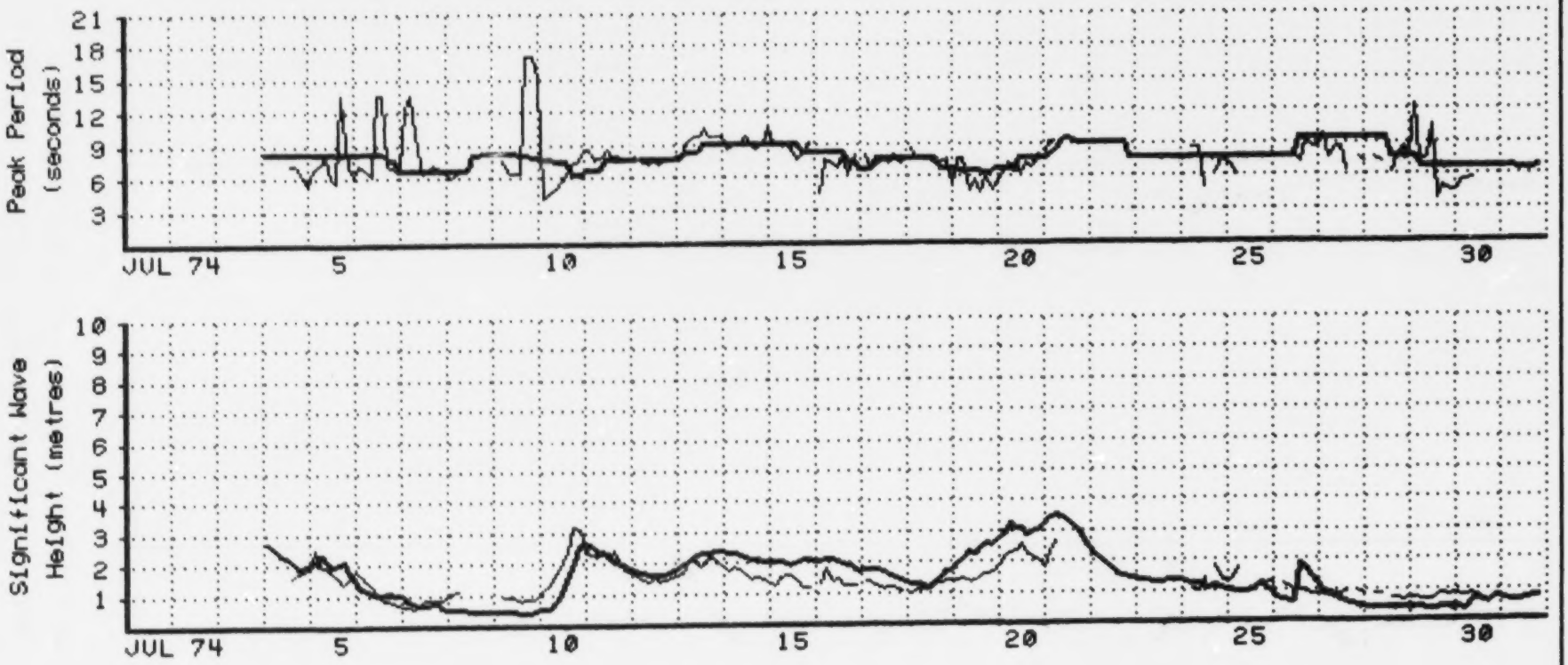
Recorded Wave File: W+MEDS.REC.91.GMT

Comment ..... : SEDCO H 91(6)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.9

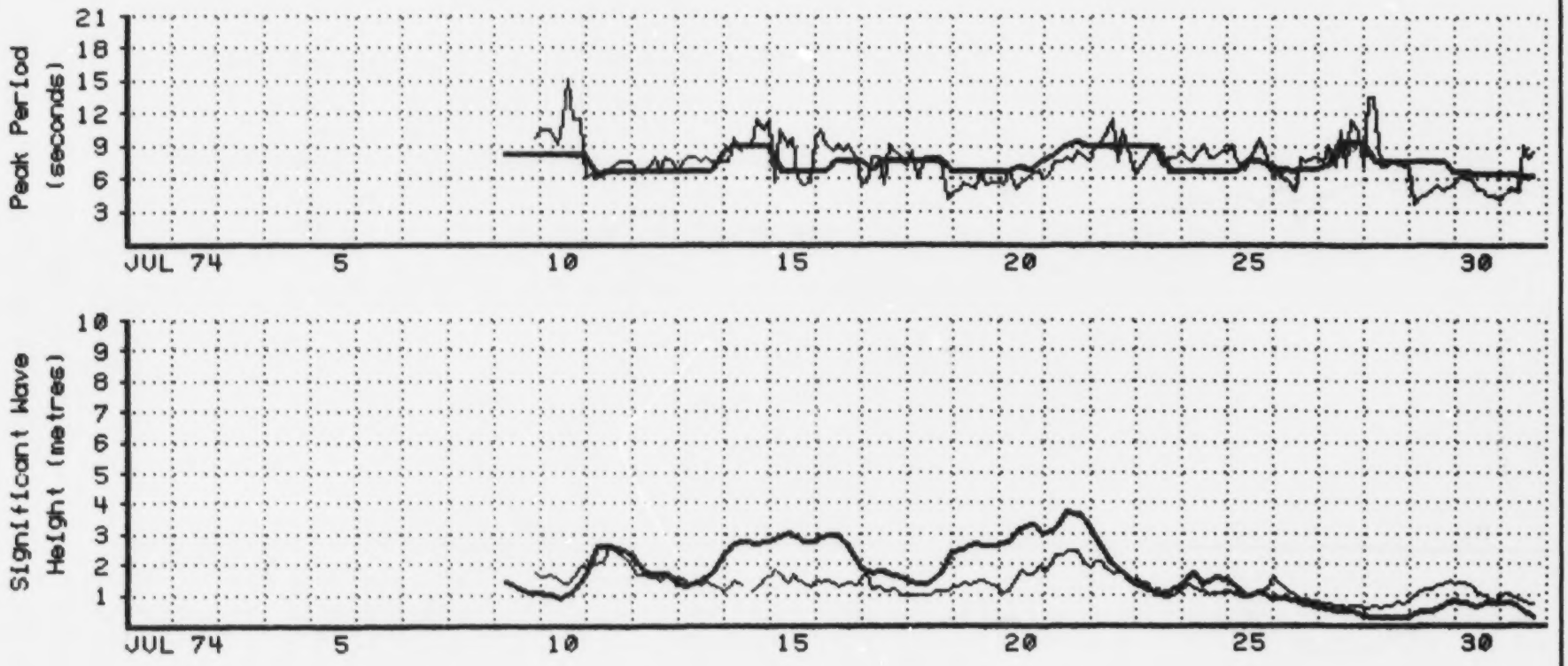
Recorded Wave File: W+MEDS.REC.91.GMT

Comment ..... : SEDCO H 91(7)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W-SI.BAIRD.5

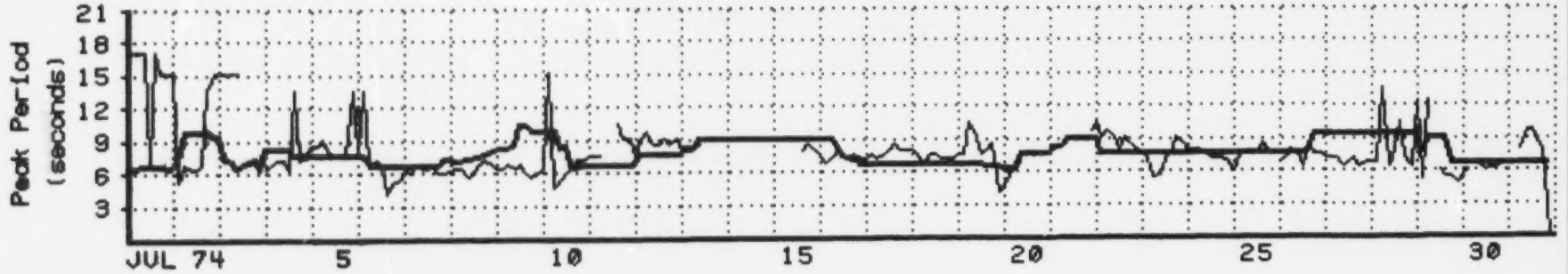
Recorded Wave File: W-MEDS.REC.94.GMT

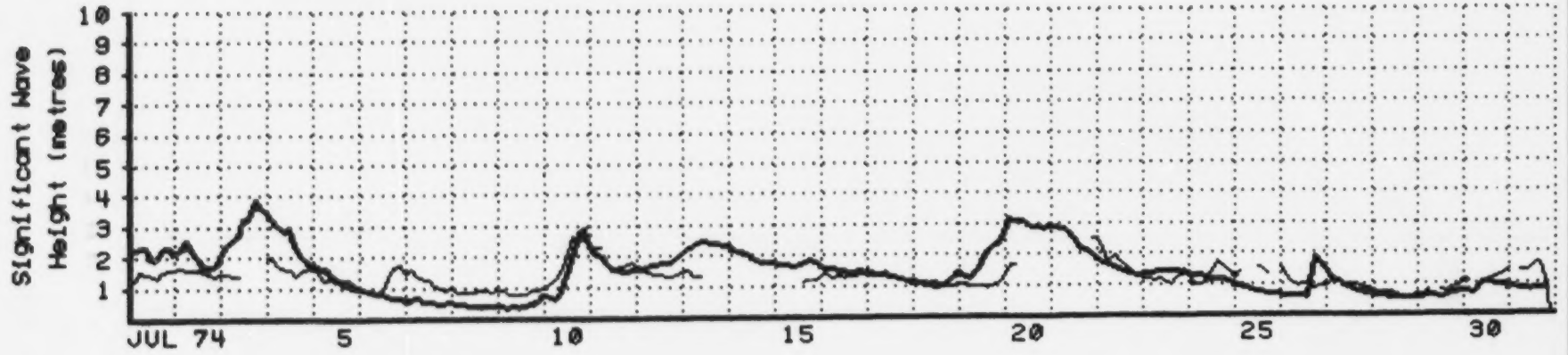
Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





Hindcast Wave File: W+SI.BAIRD.10

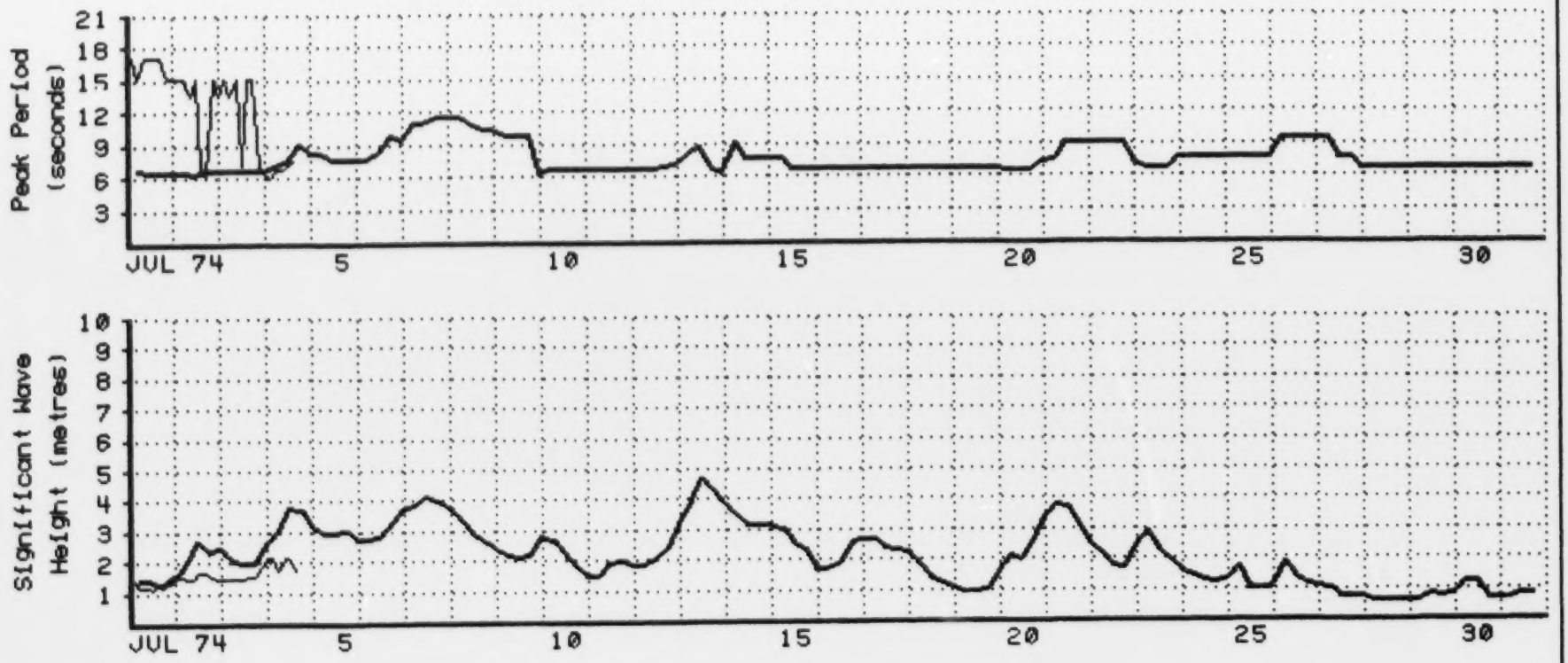
Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(5)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W←SI.BAIRD.8

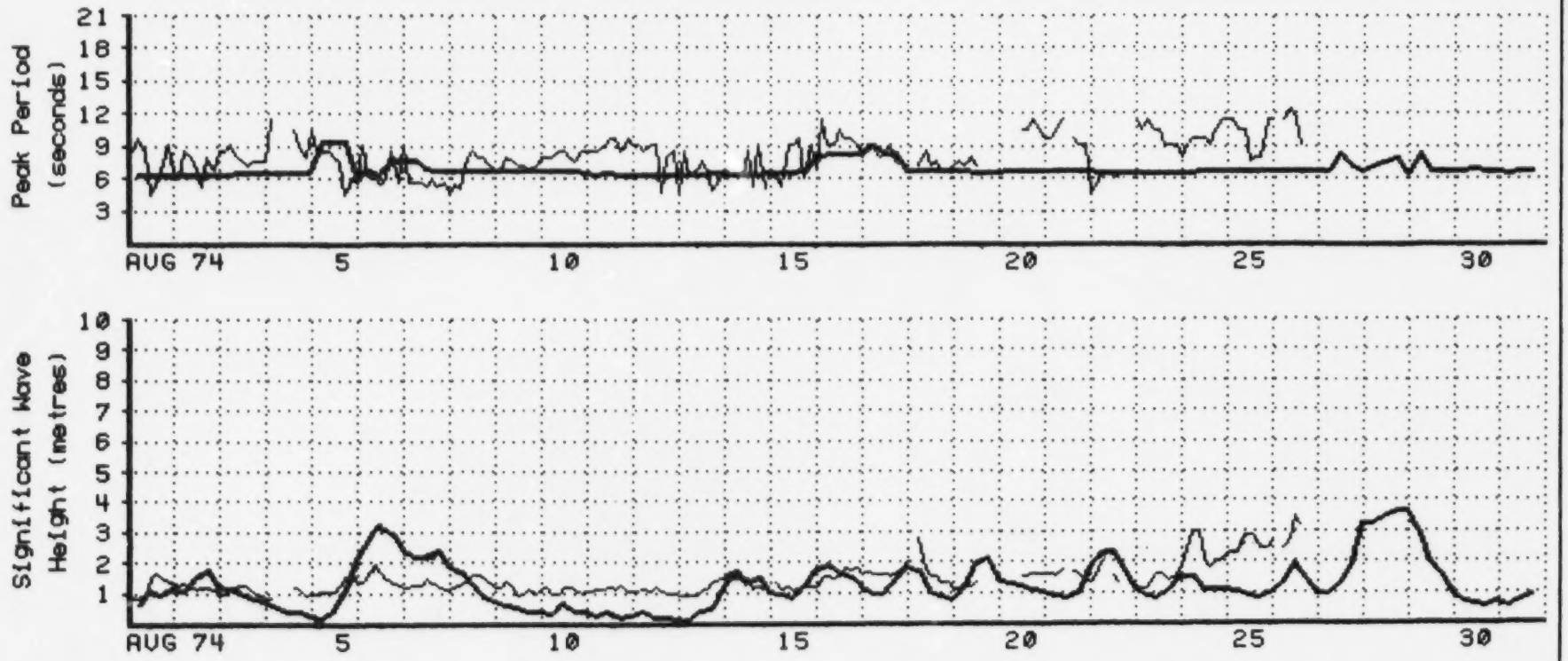
Recorded Wave File: W←MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(6)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.5

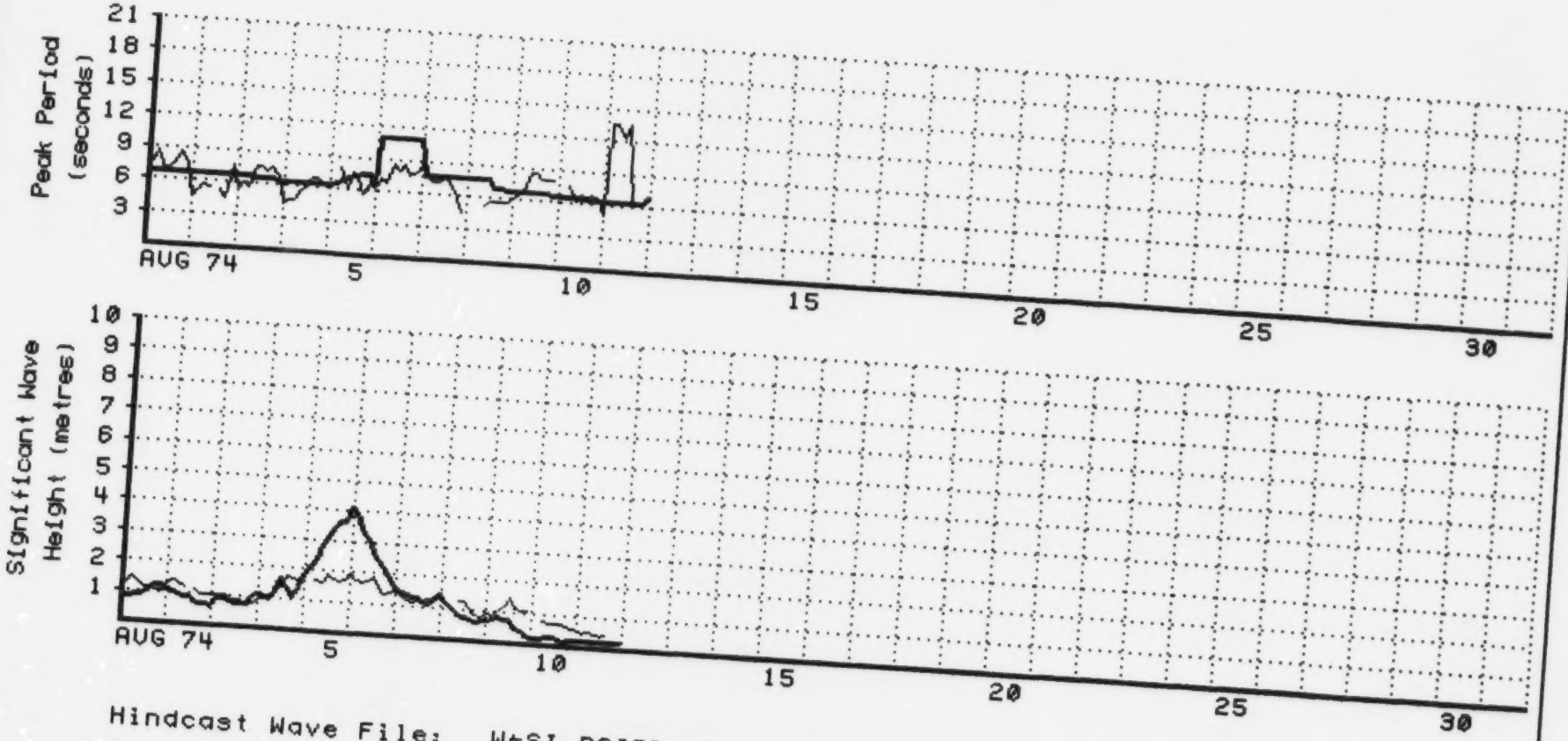
Recorded Wave File: W+MEDS.REC.94.GMT

Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



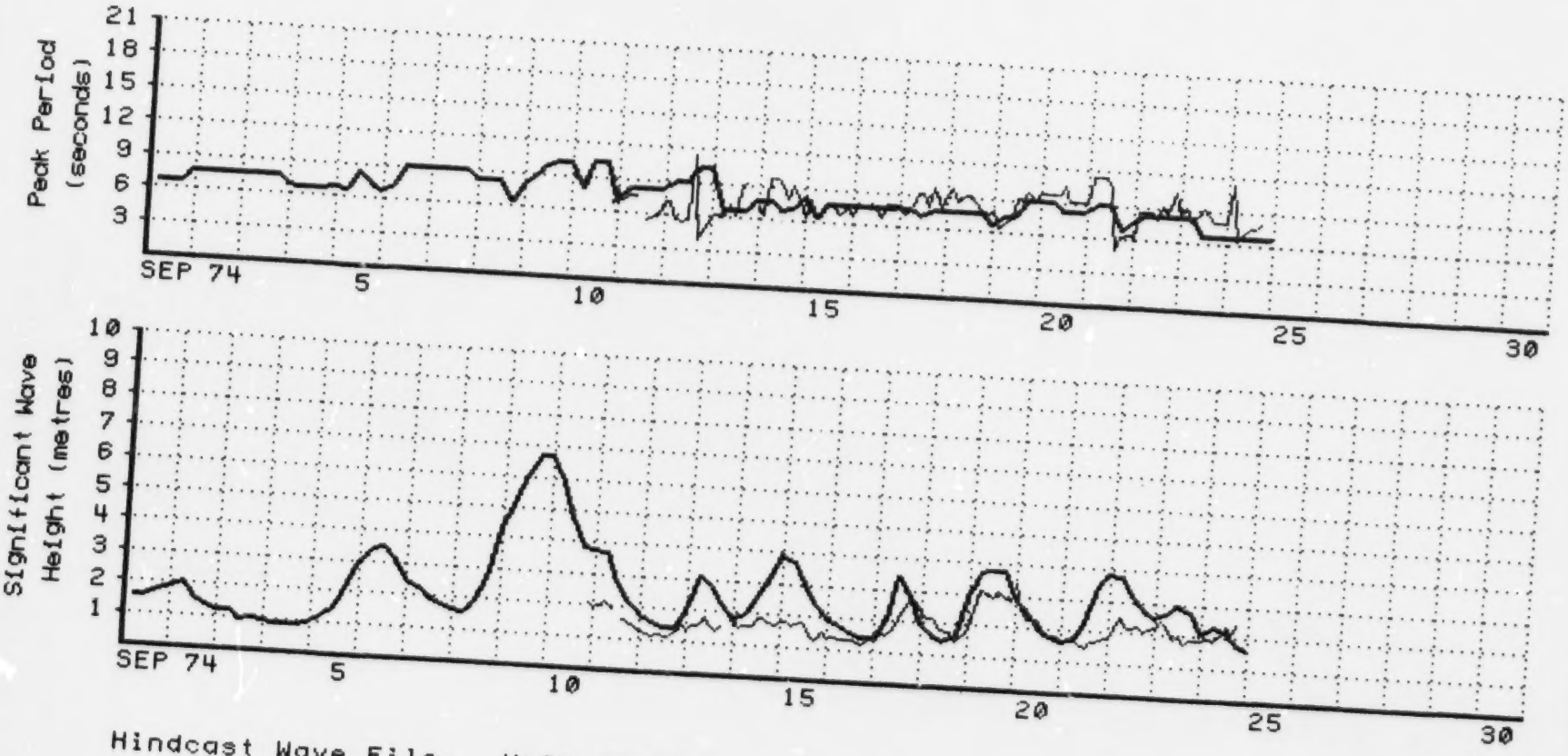
Hindcast Wave File: W+SI.BAIRD.10

Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(5)

LEGEND: — hindcast — recorded

GFC



Hindcast Wave File: W+SI.BAIRD.6

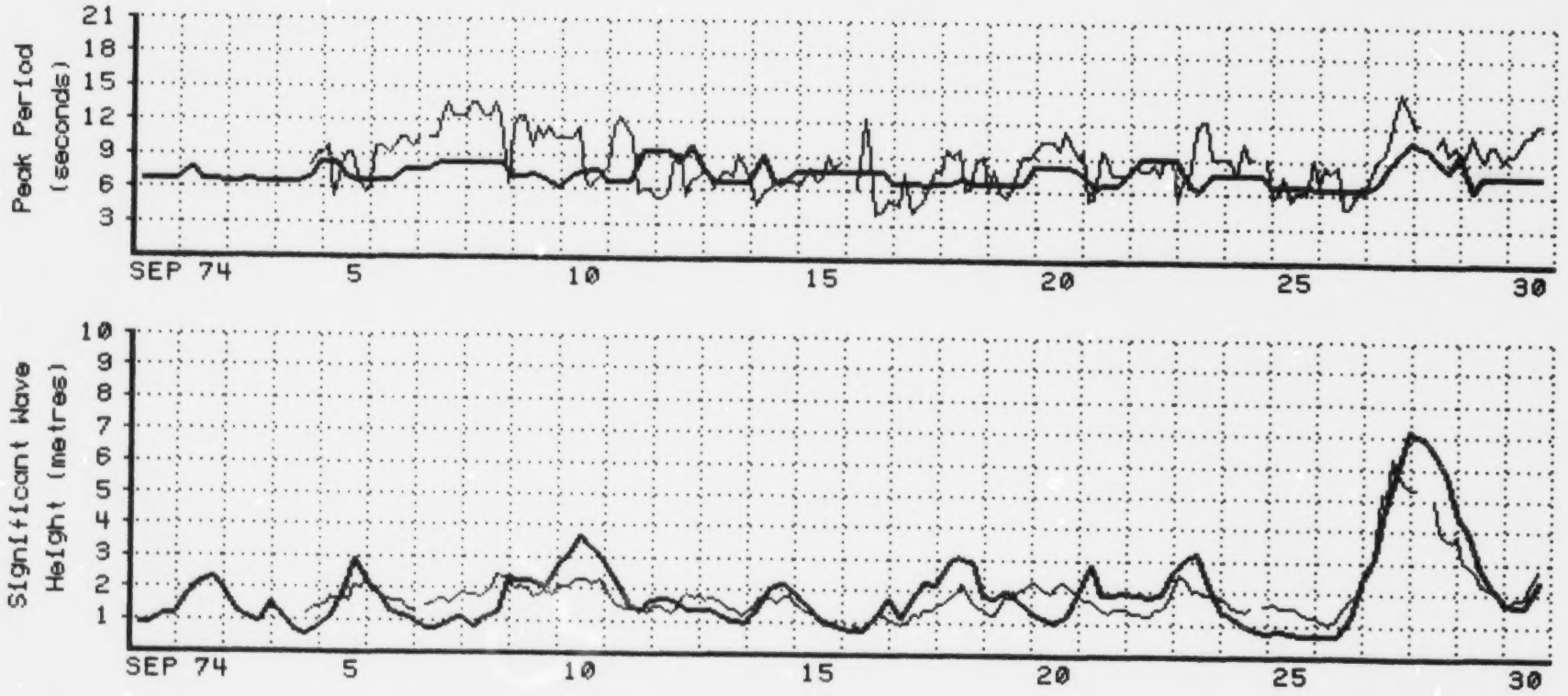
Recorded Wave File: W+MEDS.REC.93.GMT

Comment ..... : SEDCO I 93(7)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W-SI.BAIRD.5

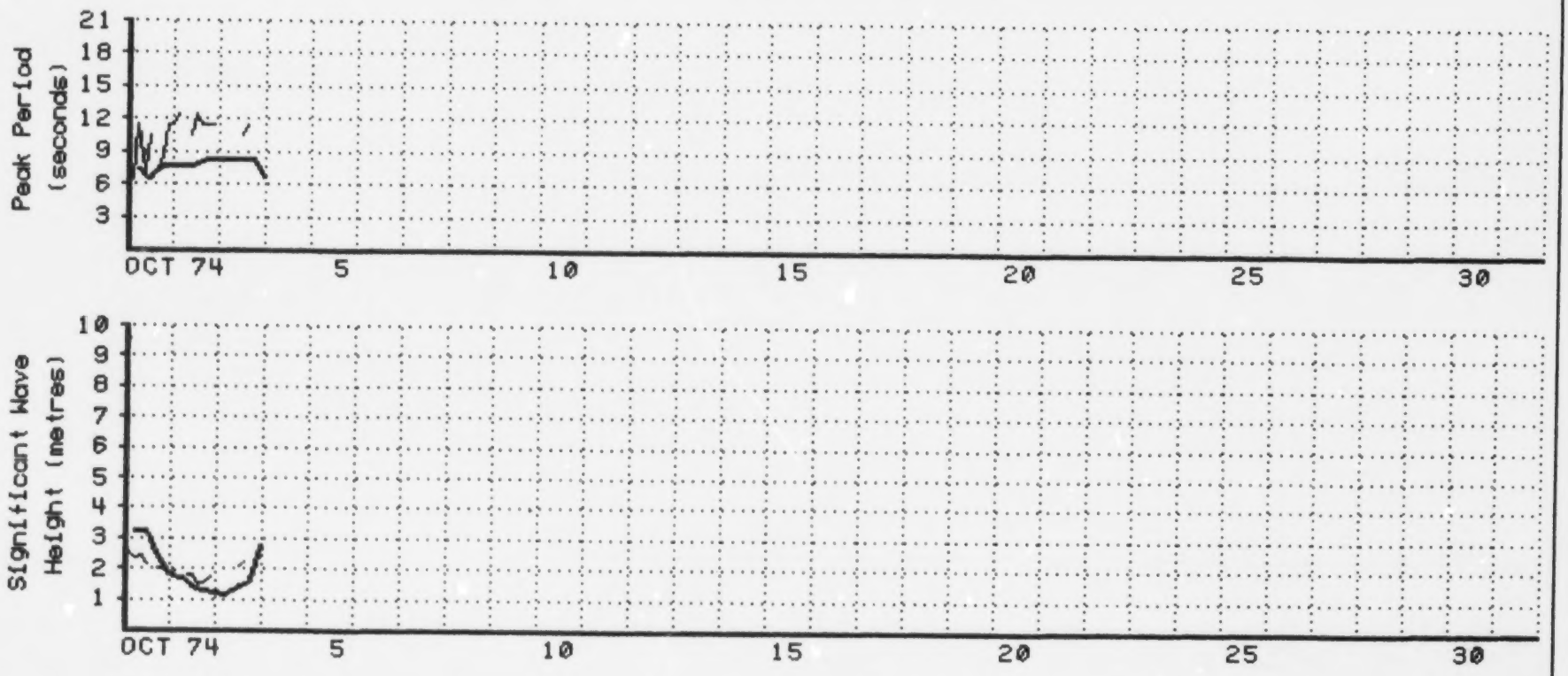
Recorded Wave File: W-MEDS.REC.94.GMT

Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.5

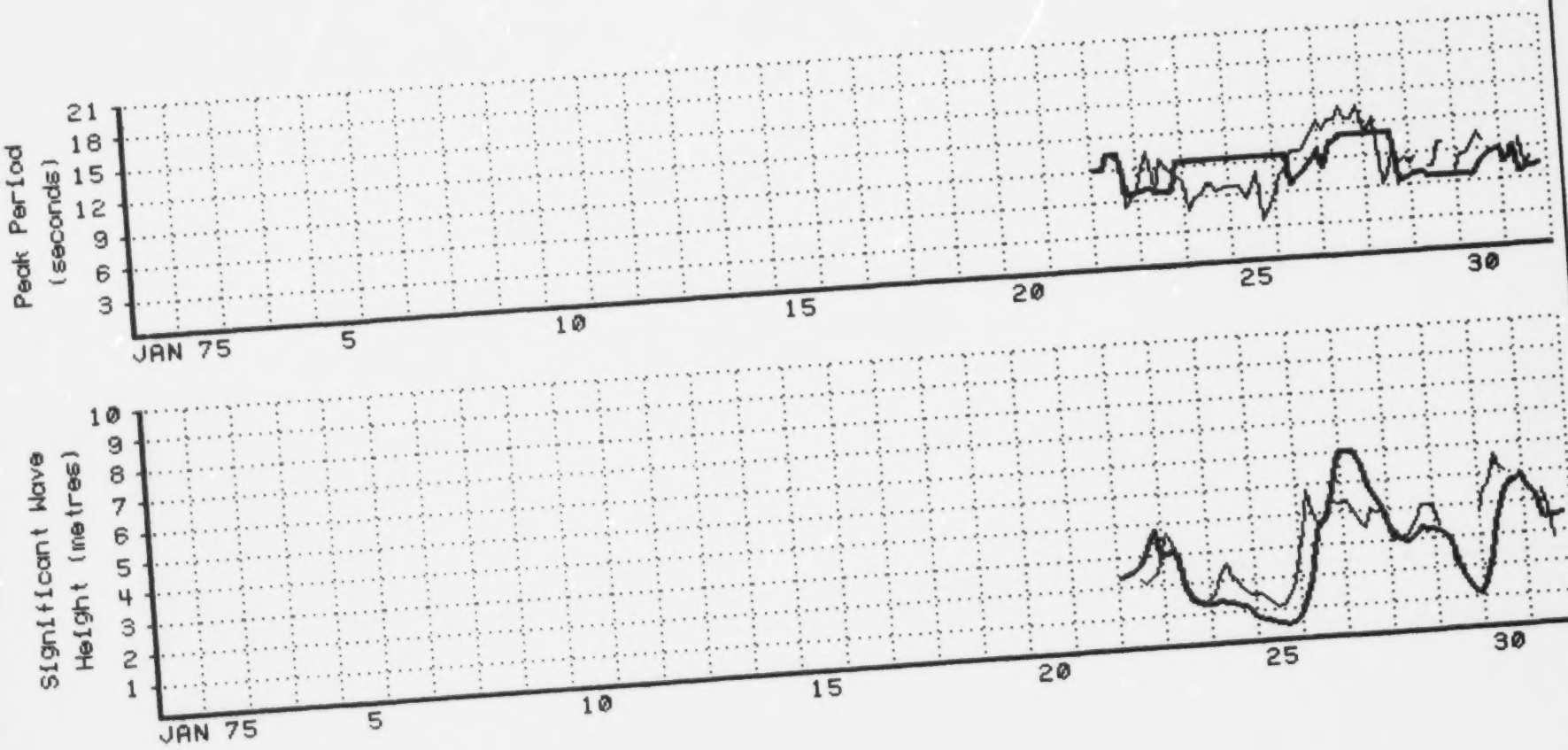
Recorded Wave File: W+MEDS.REC.94.GMT

Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



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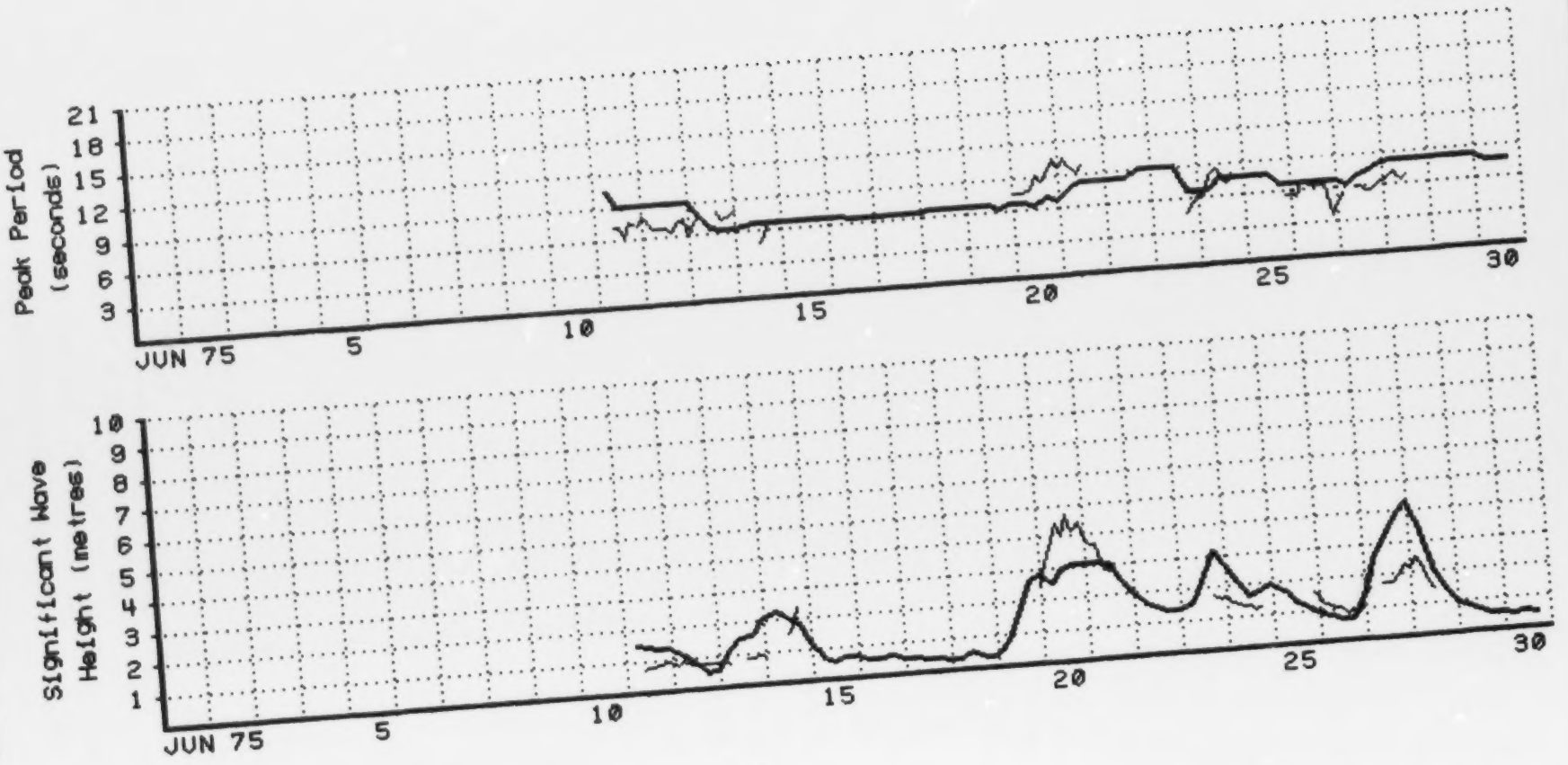
Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(7)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



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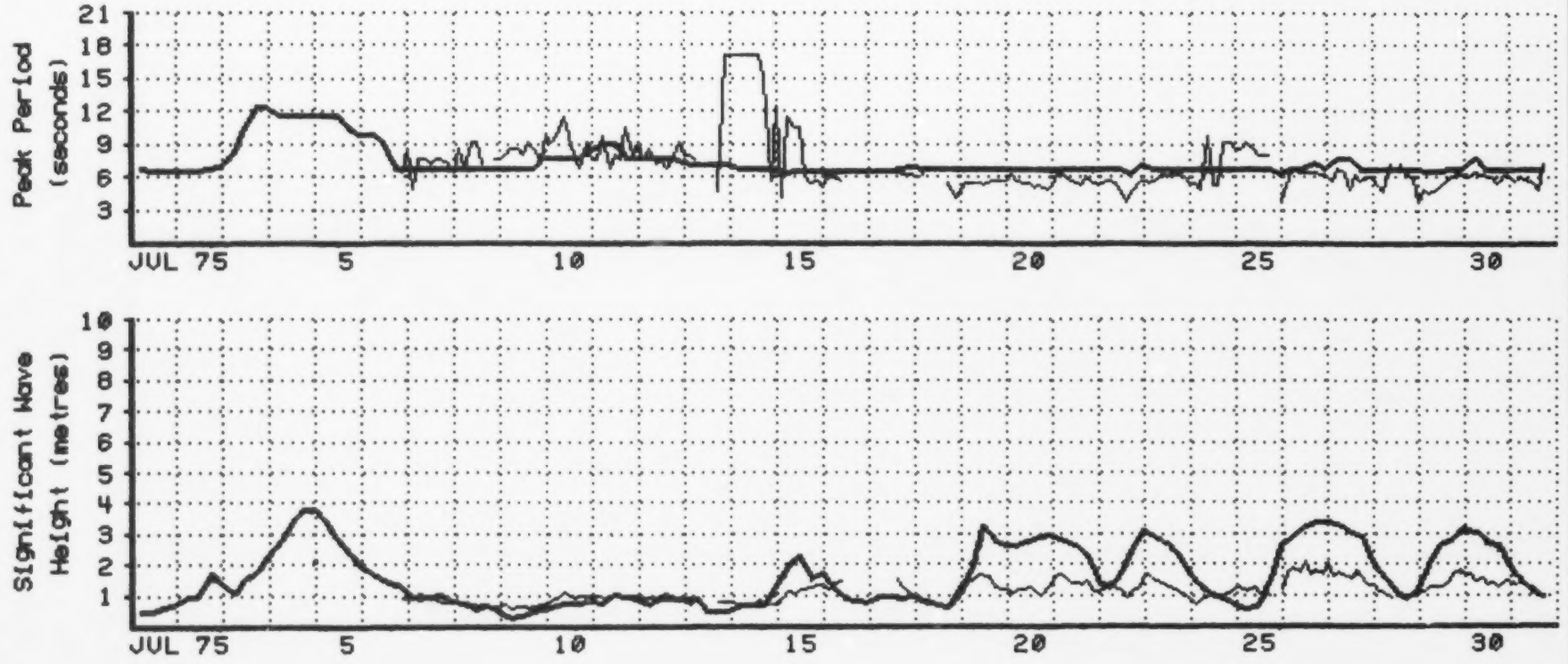
Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



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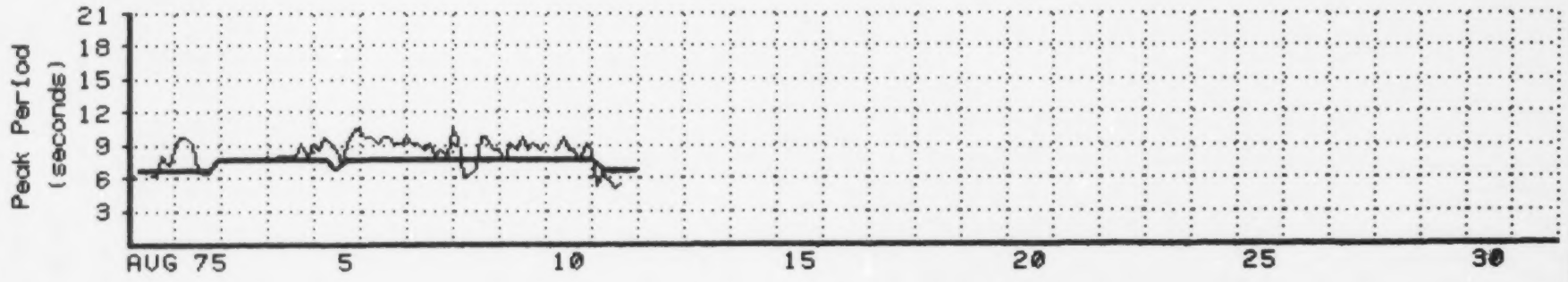
Recorded Wave File: W+MEDS.REC.94.GMT

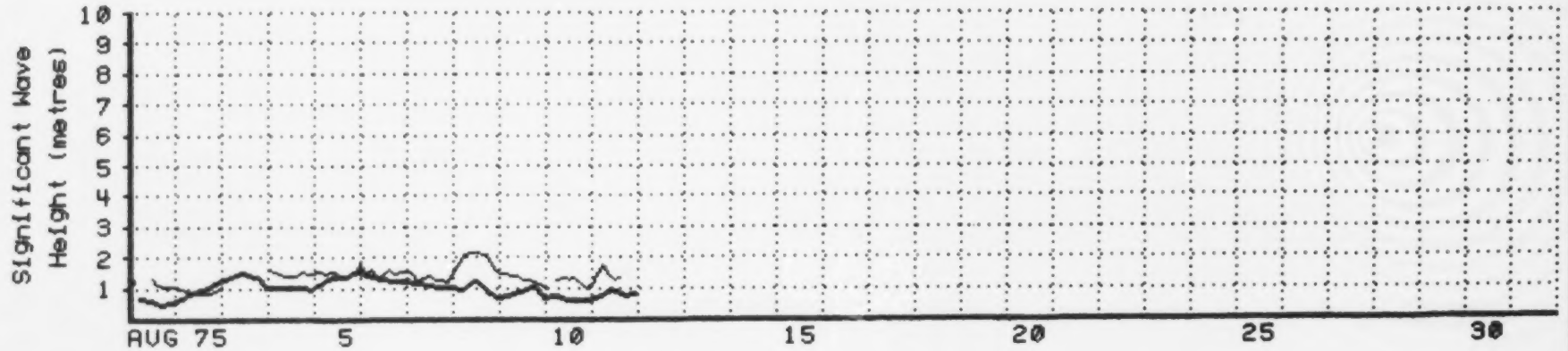
Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC





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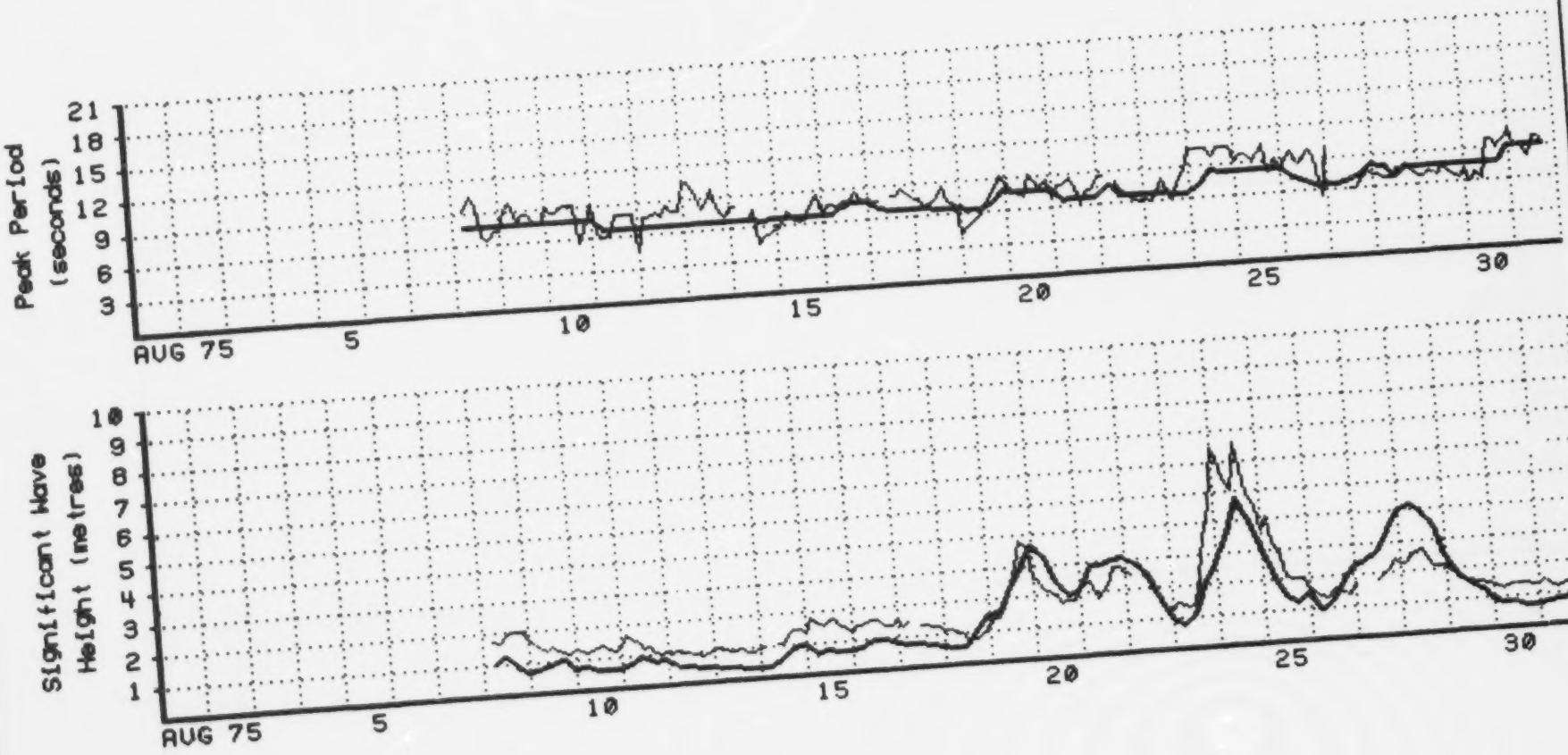
Recorded Wave File: W+MEDS.REC.94.GMT

Comment ..... : HAVDRILL 94

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



Hindcast Wave File: W+SI.BAIRD.5

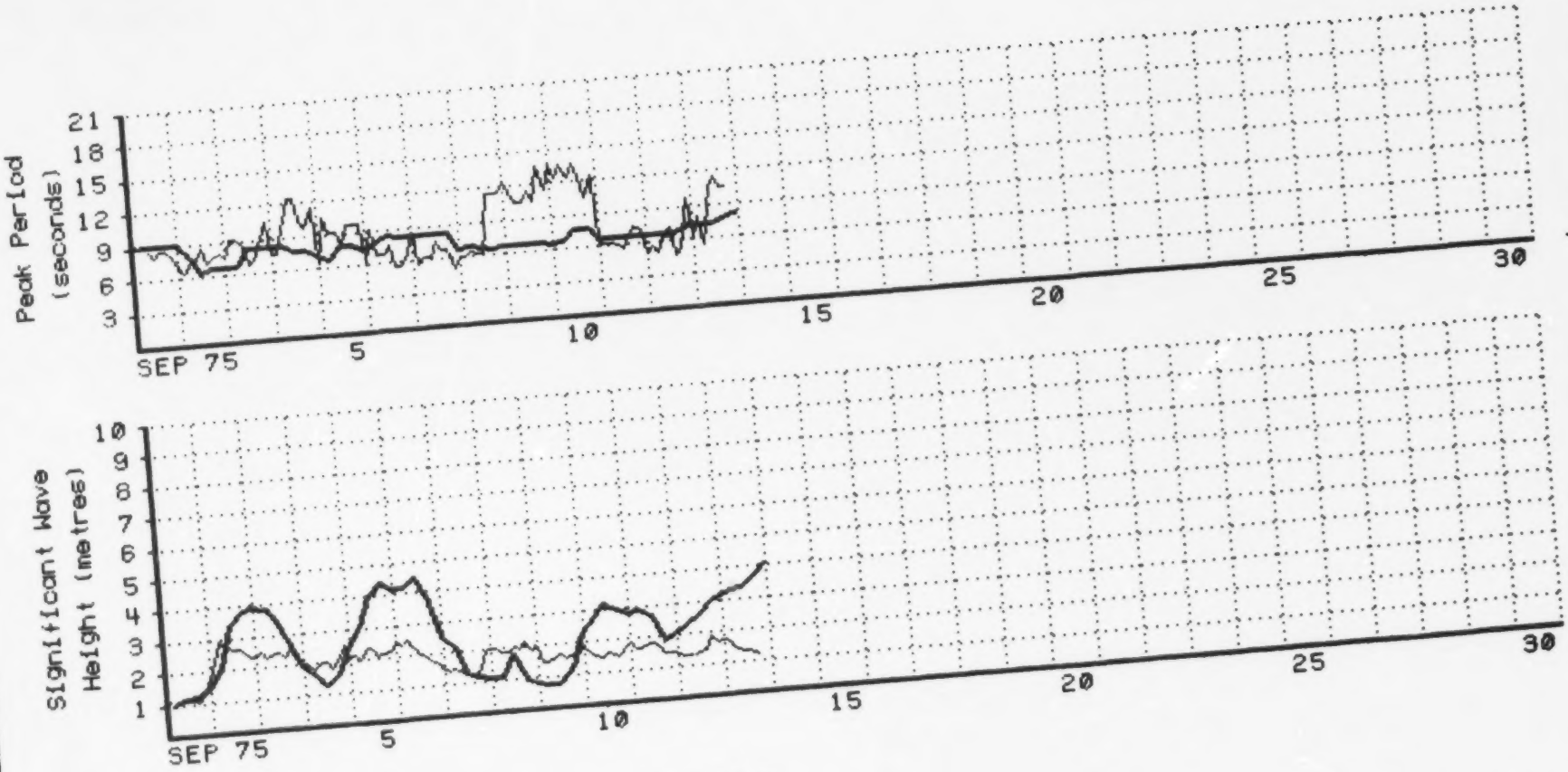
Recorded Wave File: W+MEDS.REC.90.GMT

Comment ..... : SEDCO J 90(9)

LEGEND: — hindcast — recorded

W.F. Baird & Associates

GFC



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Recorded Wave File: W+MEDS.REC.90.GMT

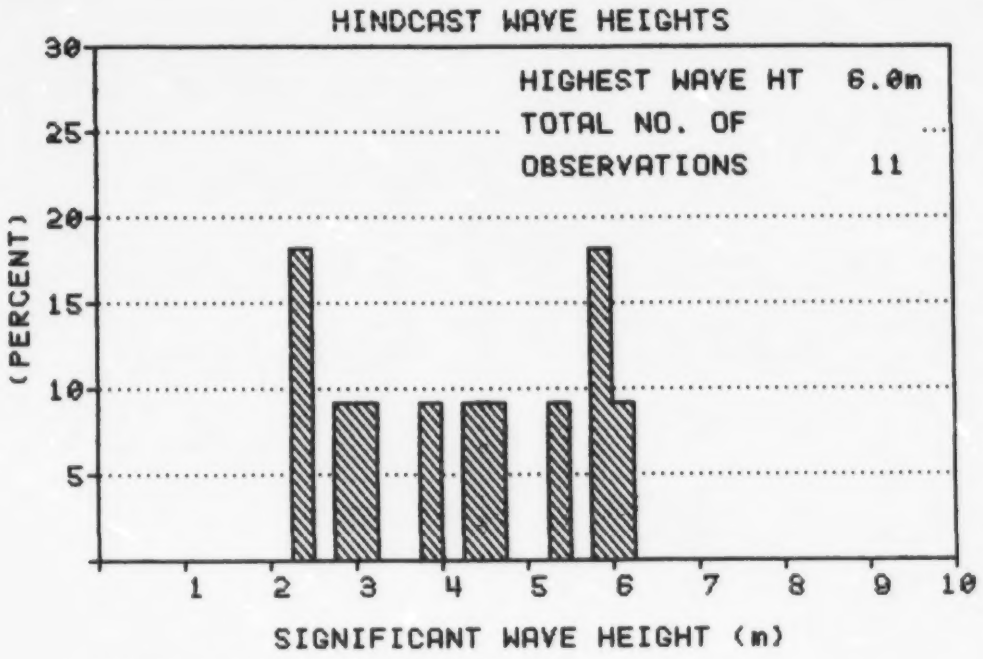
Comment ..... : SEDCO J 90(9)

LEGEND: — hindcast — recorded

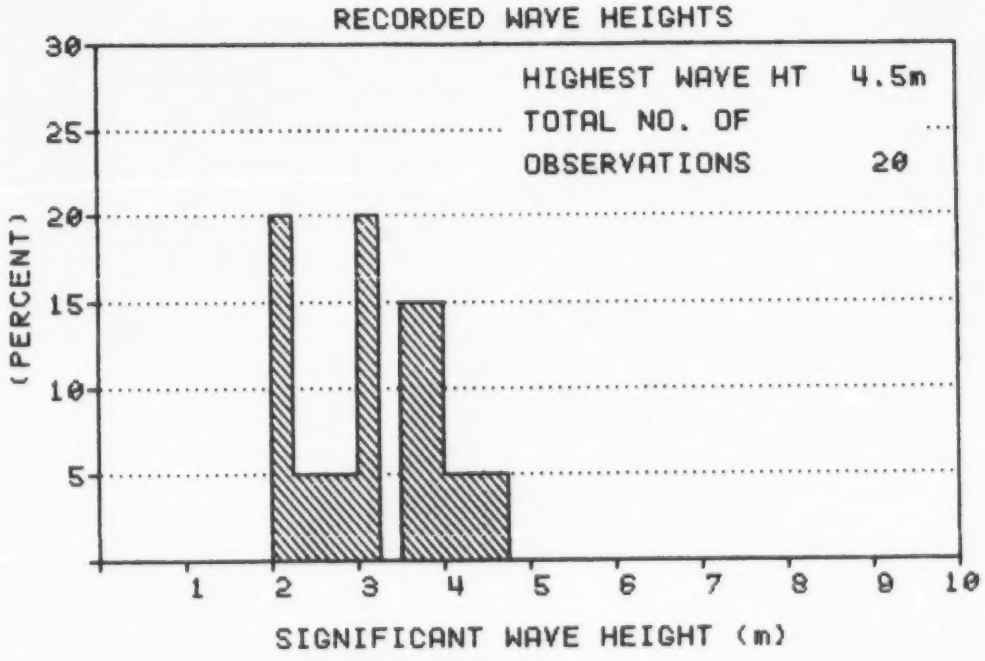
W.F. Baird & Associates

APPENDIX B

FREQUENCIES OF OCCURRENCE OF HINDCAST AND RECORDED WAVE DATA DURING SELECTED STORMS



WAVE FILE W←SI.BAIRD.6



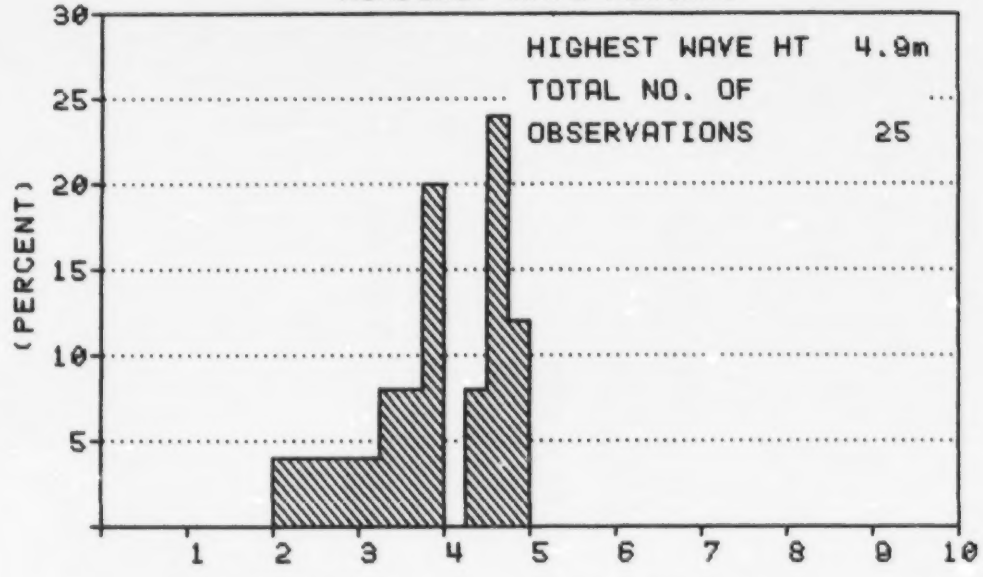
WAVE FILE W←MEDS.REC.93.GMT

STORM DURATION 73 09 05 12 - 73 09 07 24
LOCATION HINDCAST STA 6 / SEDCO I 93(1)

GFC

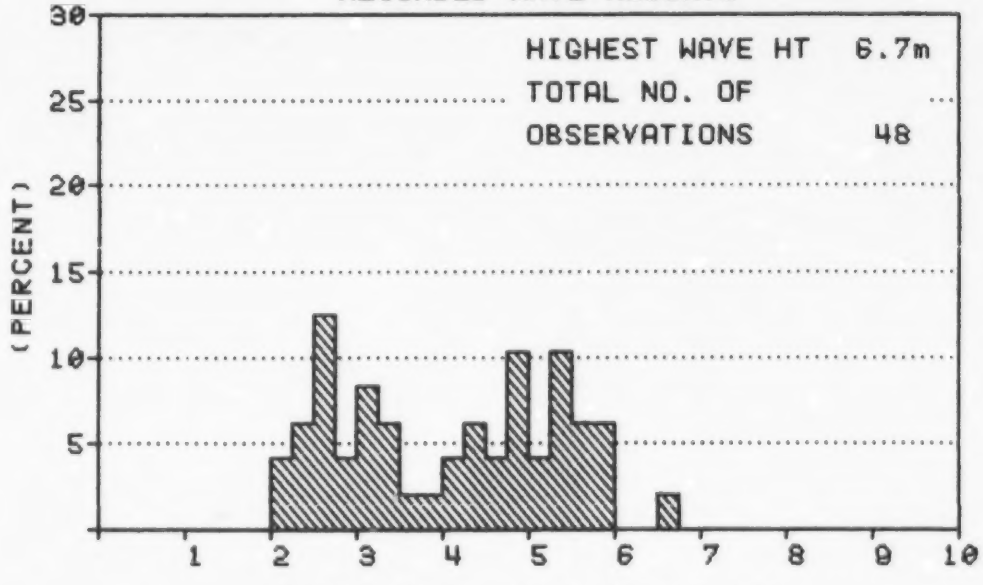
W.F.Baird Associates

HINDCAST WAVE HEIGHTS



WAVE FILE W-SI.BAIRD.6A

RECORDED WAVE HEIGHTS

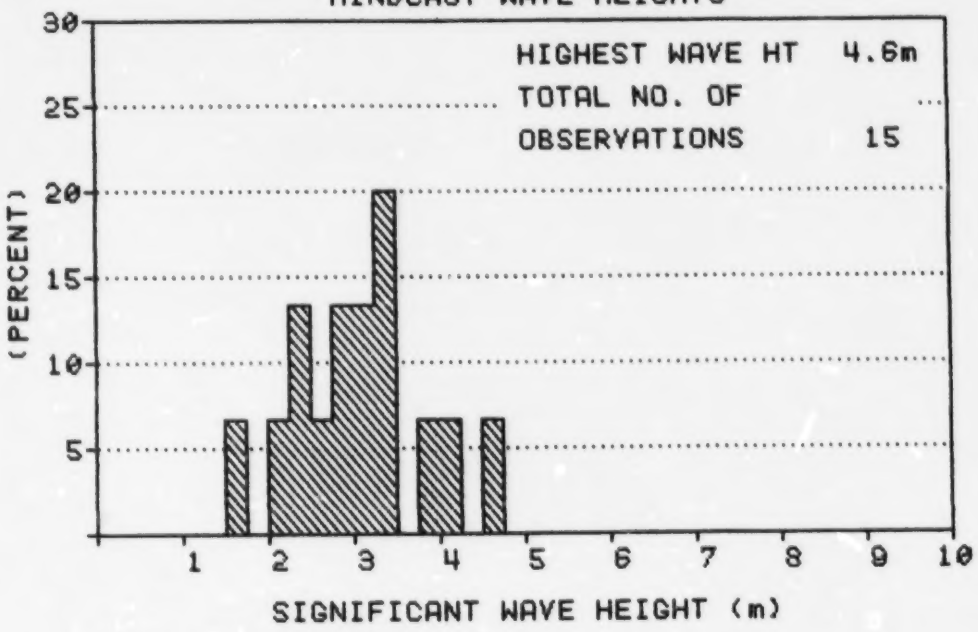


WAVE FILE W-MEDS.REC.93.GMT

STORM DURATION 73 10 07 12 - 73 10 13 12
LOCATION HINDCAST STA 6 / SEDCO I 93(2)

GFC

HINDCAST WAVE HEIGHTS



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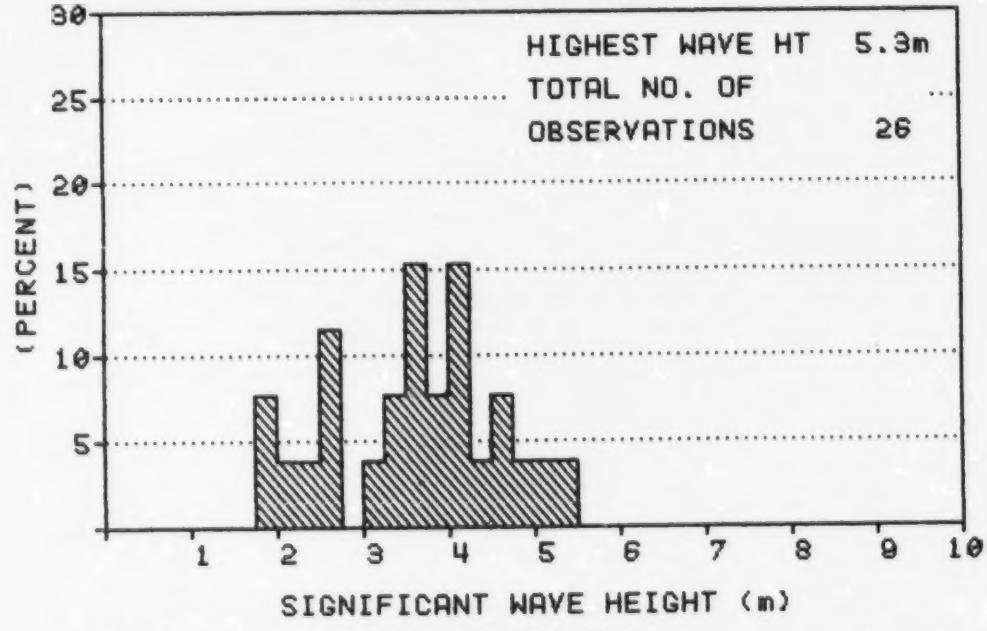
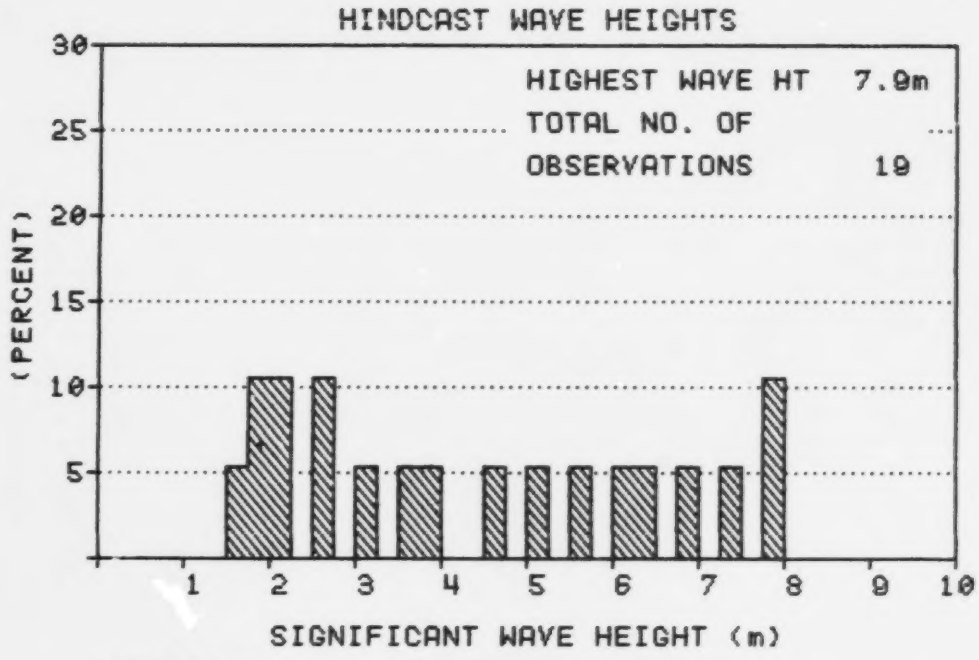


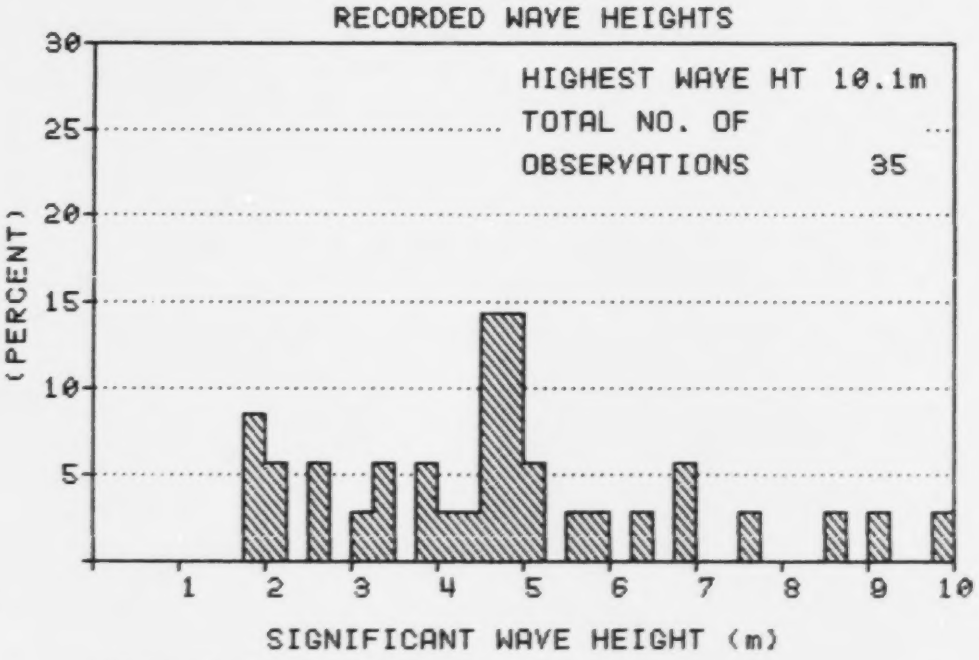
WAVE FILE W-MEDS.REC.00.GMT

STORM DURATION 73 10 21 24 - 73 10 25 12
LOCATION HINDCAST STA 6 / SEDCO J 00(2)

GFC



WAVE FILE W←SI.BAIRD.6A

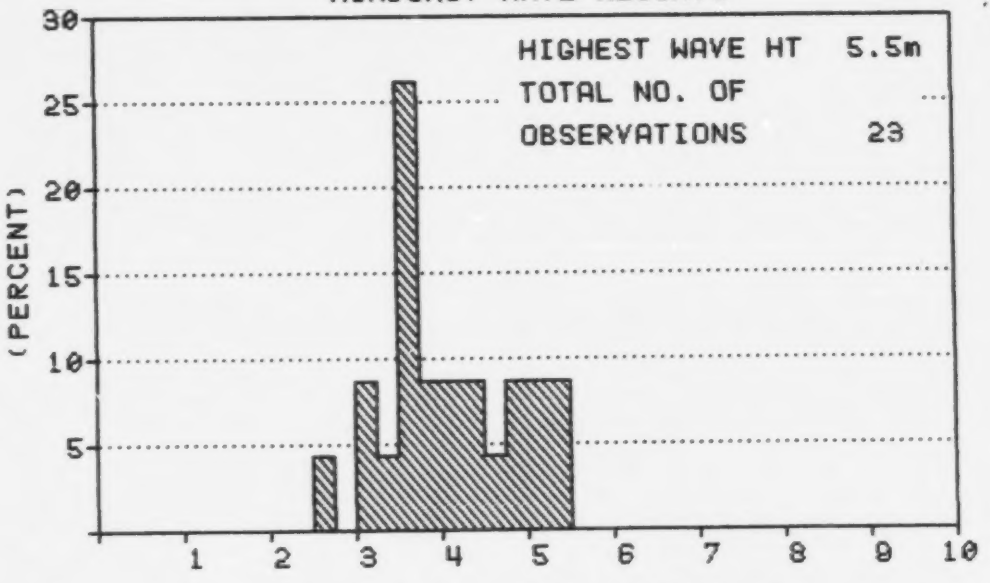


WAVE FILE W←MEDS.REC.00.GMT

STORM DURATION 73 10 26 24 - 73 10 31 12
LOCATION HINDCAST STA 6 / SEDCO J 90(2)

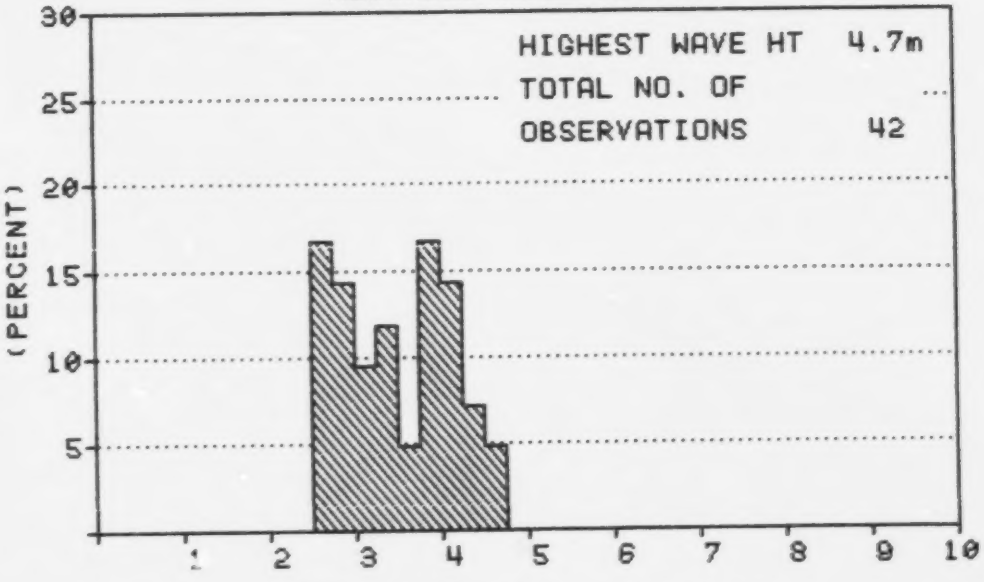
GFC

HINDCAST WAVE HEIGHTS



WAVE FILE W-SI.BAIRD.6A

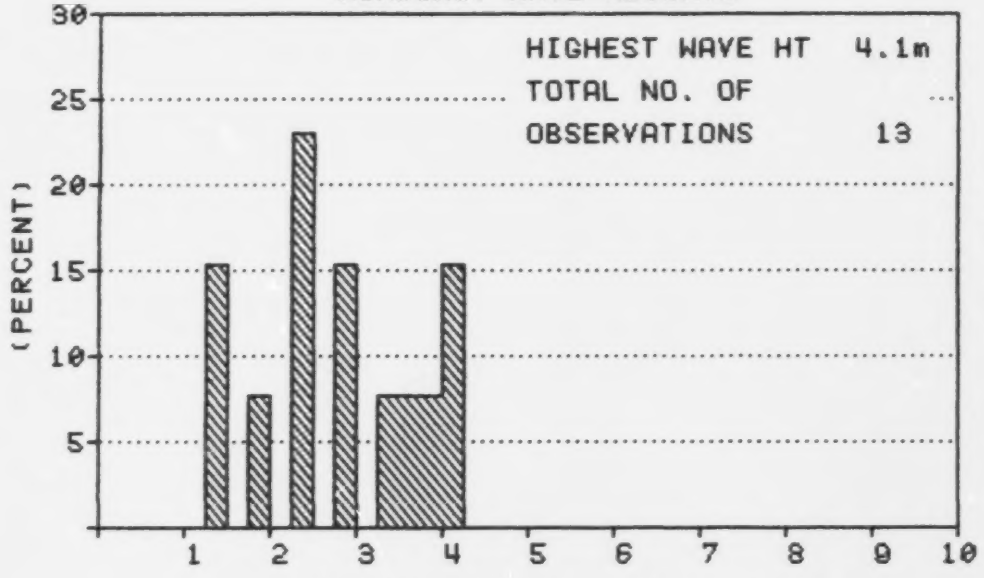
RECORDED WAVE HEIGHTS



WAVE FILE W-MEDS.REC.00.GMT

STORM DURATION 73 11 02 12 - 73 11 07 24
LOCATION HINDCAST STA 6 / SEDCO J 90(2)

HINDCAST WAVE HEIGHTS



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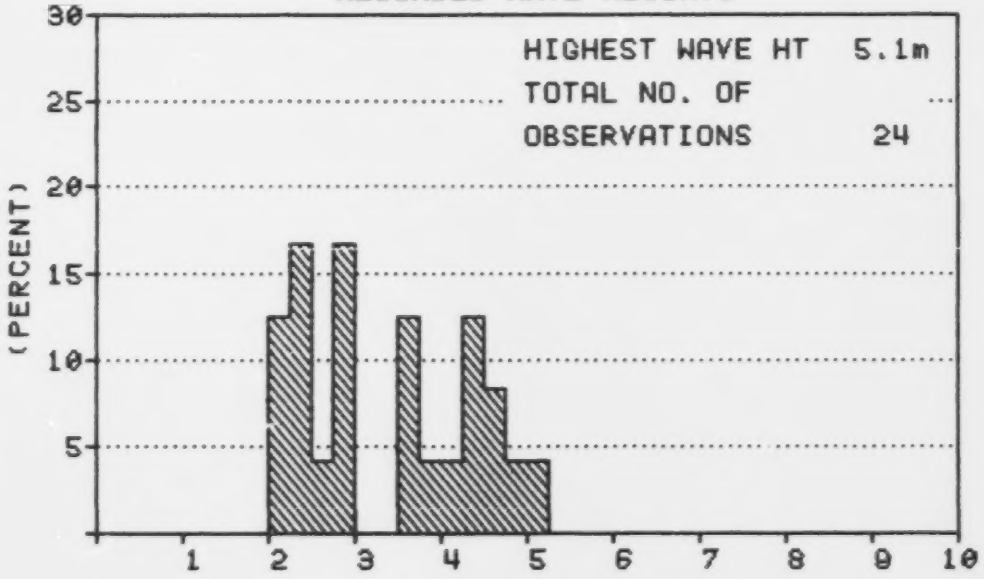
RECORDED WAVE HEIGHTS



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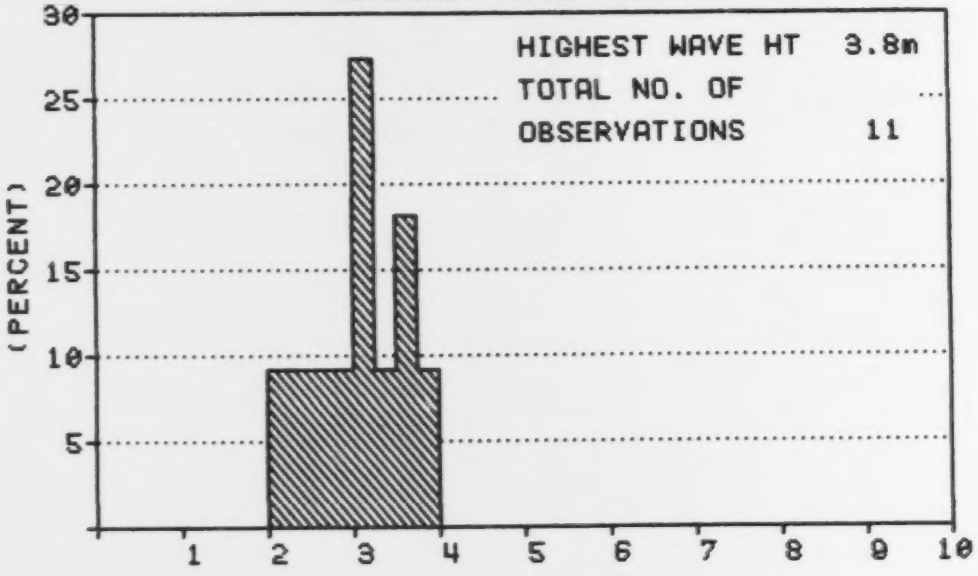
LOCATION HINDCAST STA 6 / SEDCO J 90(2)

HINDCAST WAVE HEIGHTS



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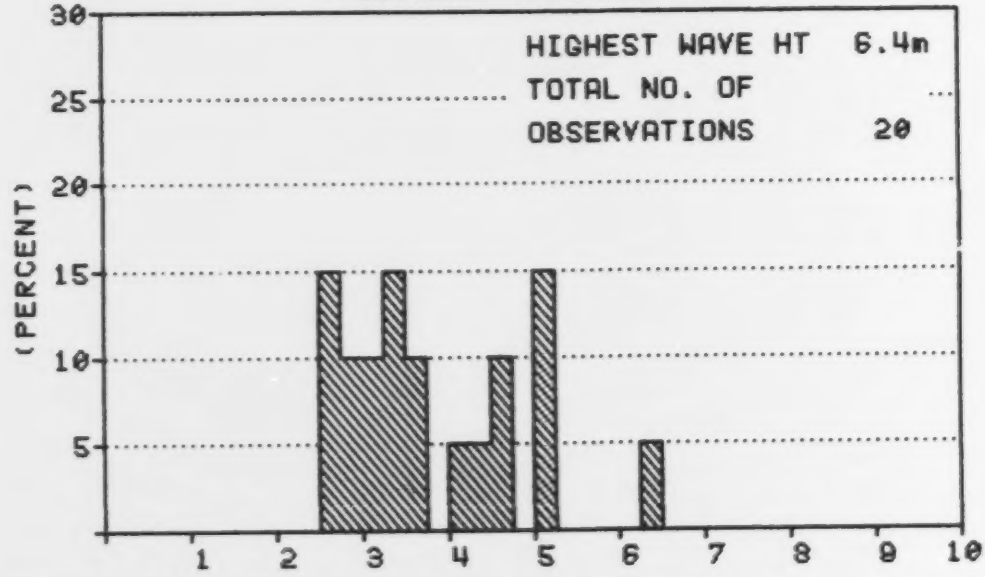
RECORDED WAVE HEIGHTS



WAVE FILE W-MEDS.REC.90.GMT

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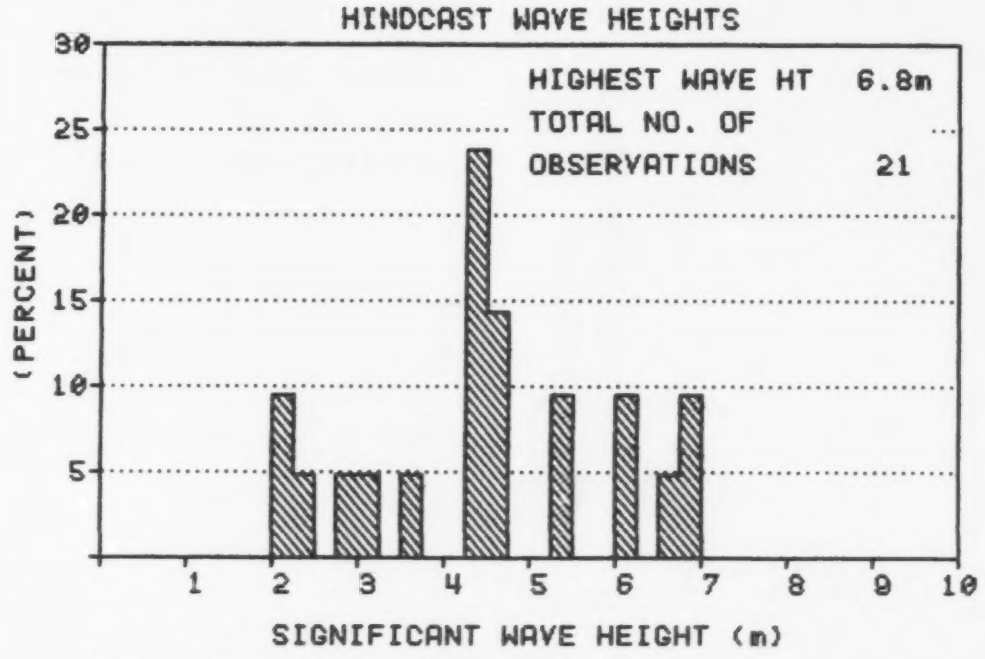
LOCATION HINDCAST STA 6 / SEDCO J 90(2)



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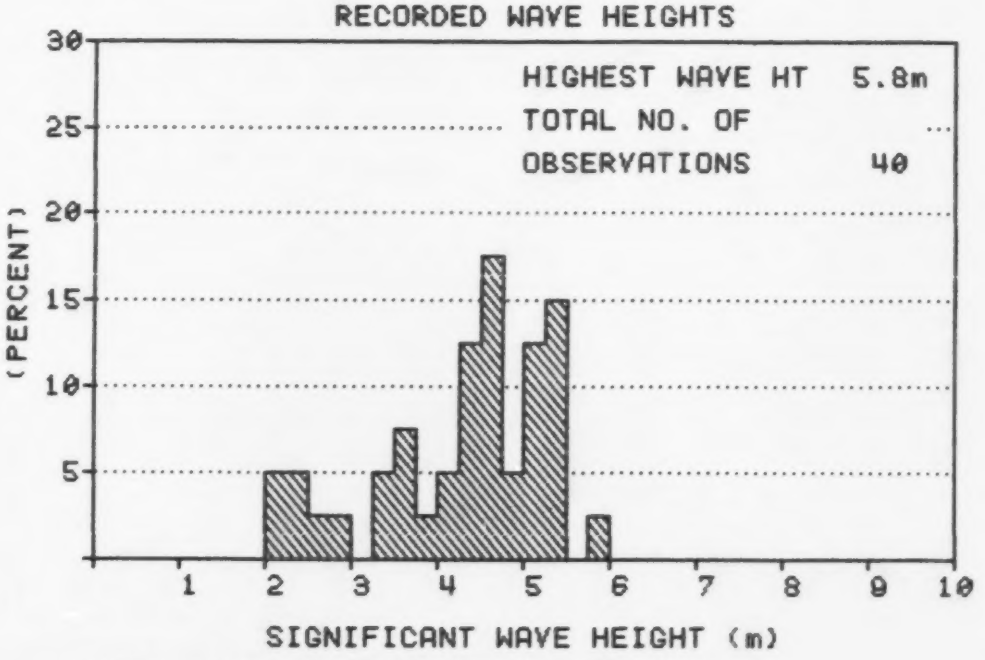

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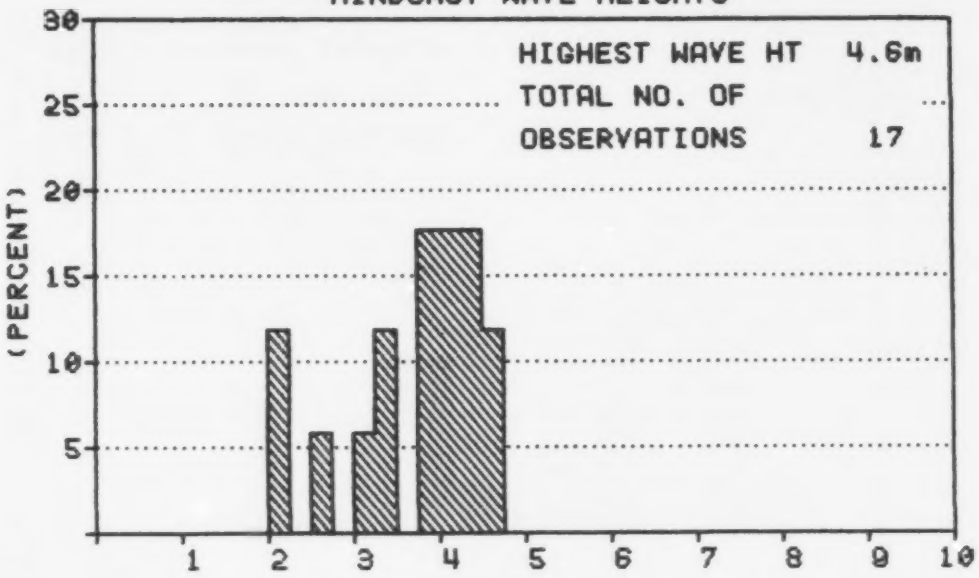
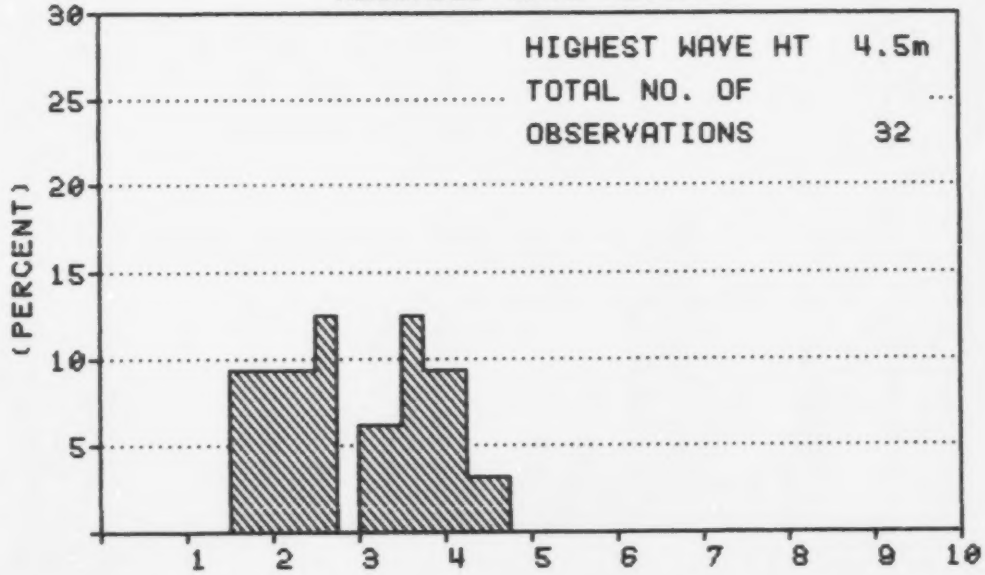
STORM DURATION 73 11 20 24 - 73 11 25 24
LOCATION HINDCAST STA 6 / SEDCO J 90(2)

HINDCAST WAVE HEIGHTS



WAVE FILE W-SI.BAIRD.8A

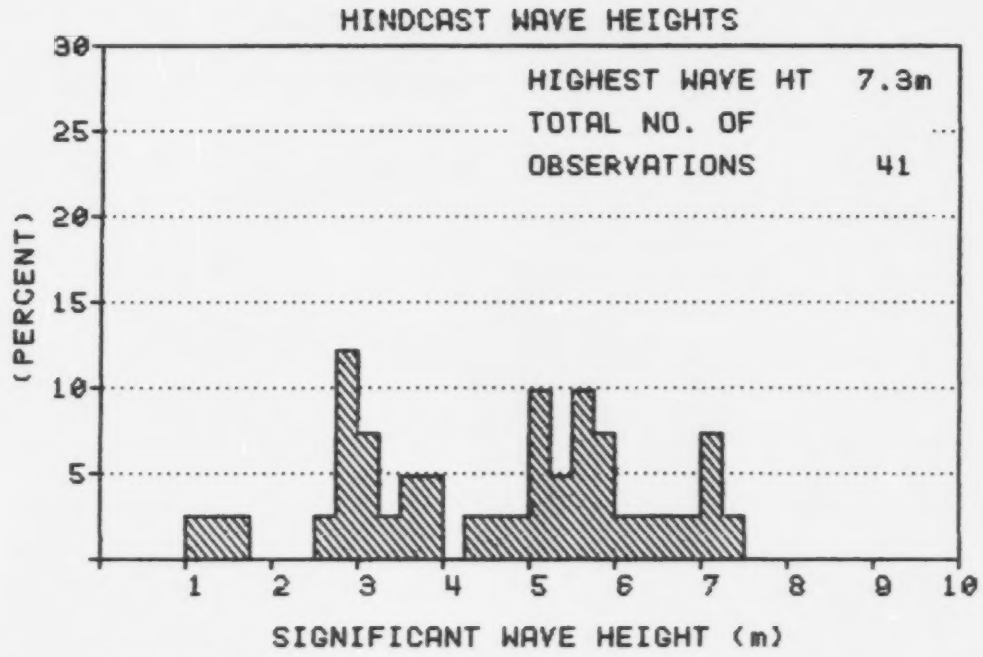
RECORDED WAVE HEIGHTS



WAVE FILE W-MEDS.REC.93.GMT

STORM DURATION 73 12 02 24 - 73 12 06 24
LOCATION HINDCAST STA 8 / SEDCO I 93(4)

GFC



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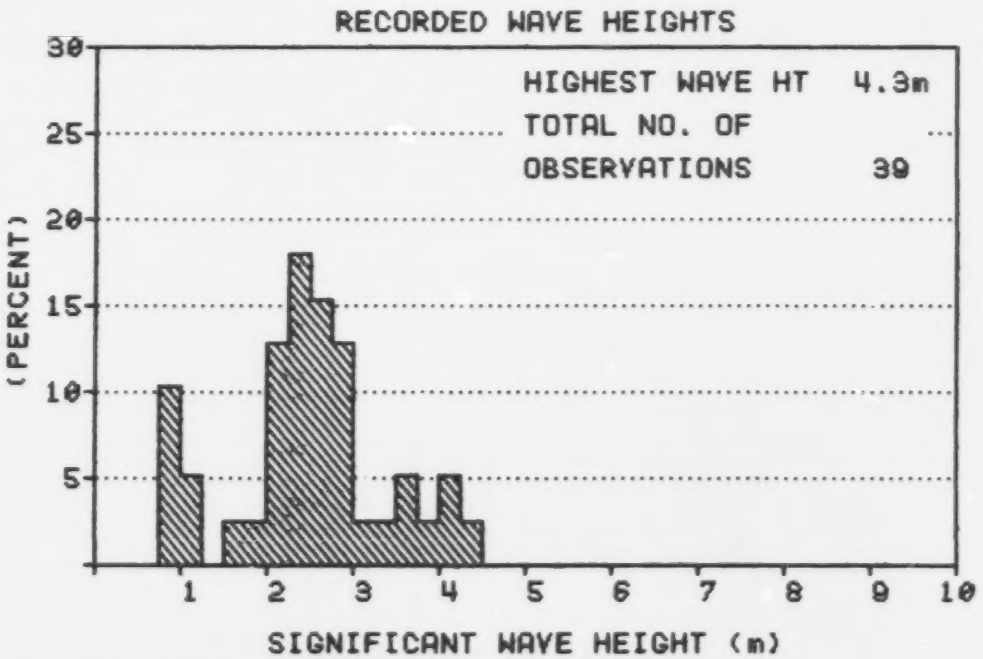
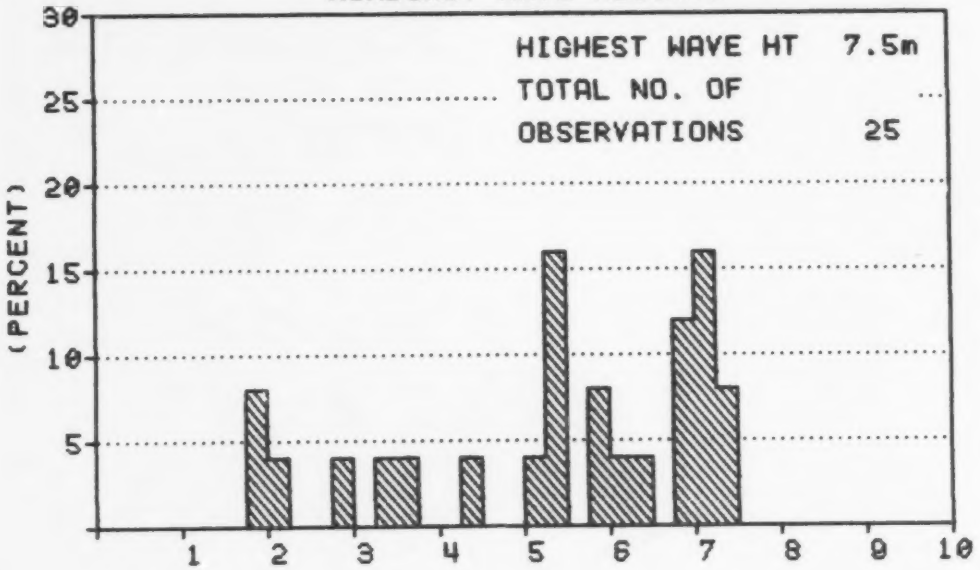


WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 73 12 09 24 - 73 12 14 24
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

HINDCAST WAVE HEIGHTS



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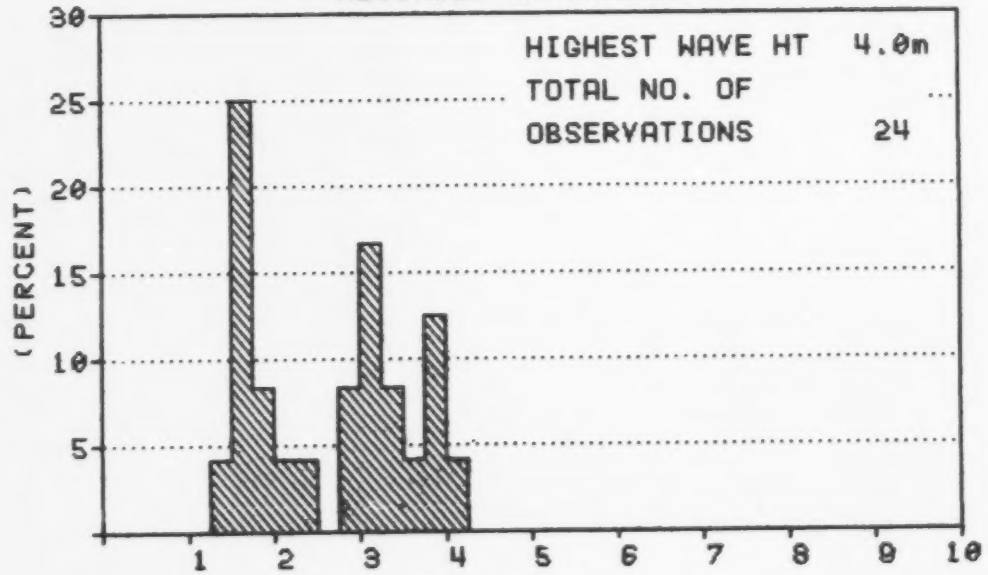

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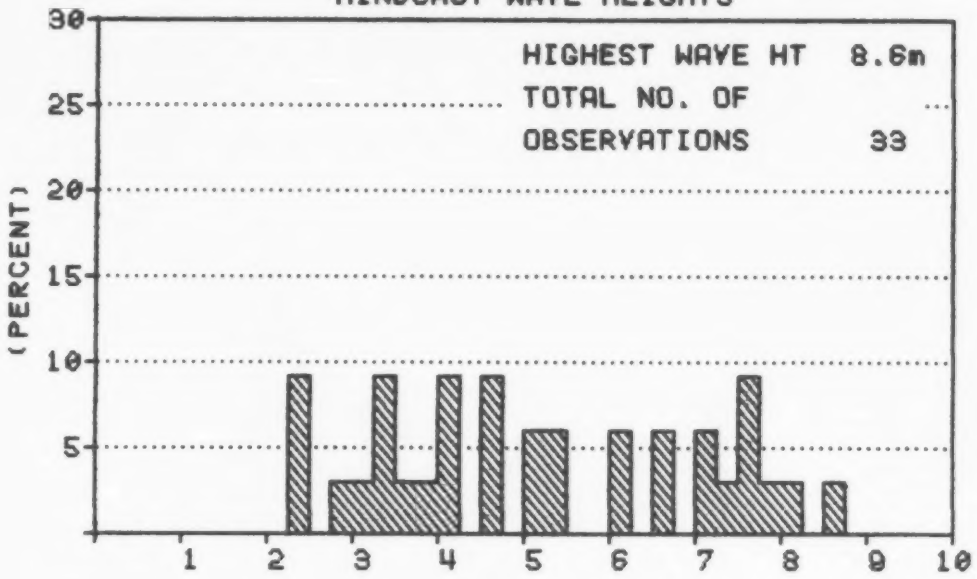
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

HINDCAST WAVE HEIGHTS



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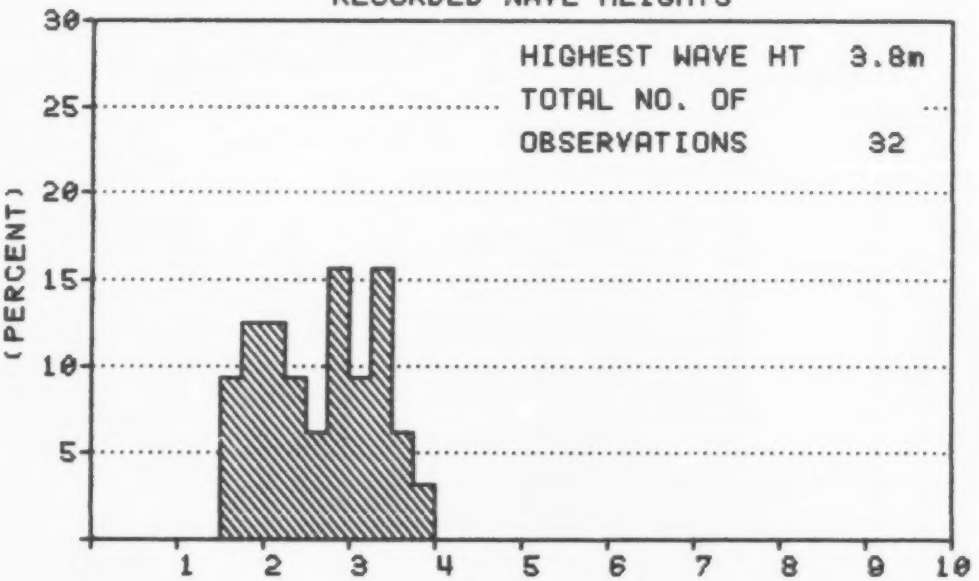
RECORDED WAVE HEIGHTS



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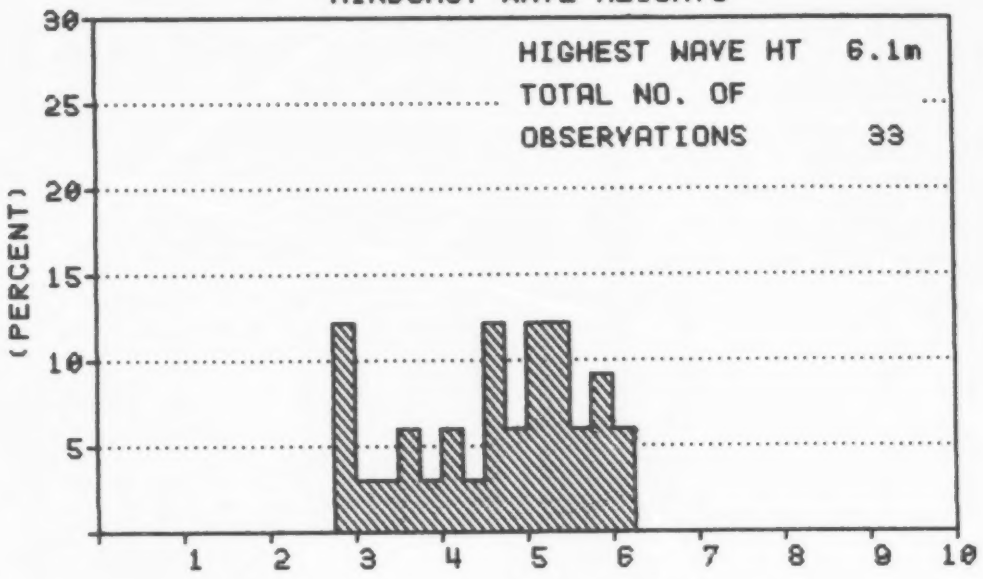
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

HINDCAST WAVE HEIGHTS



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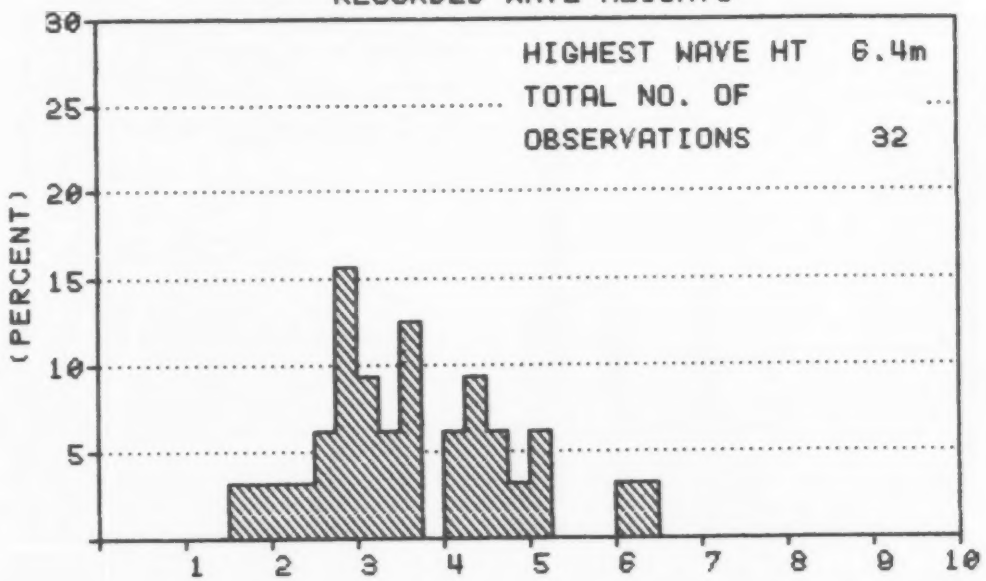
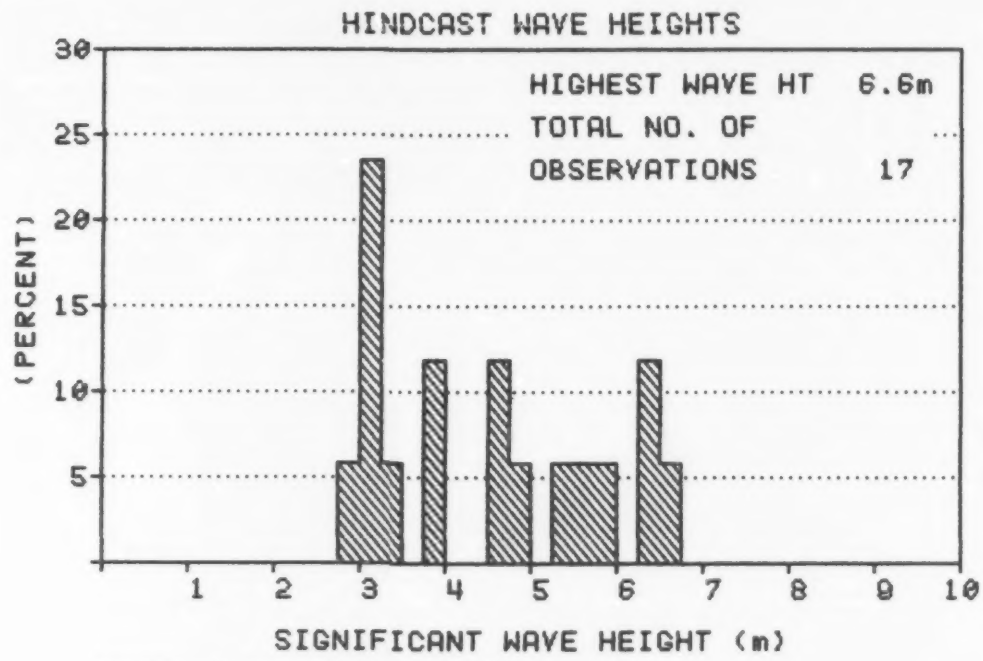
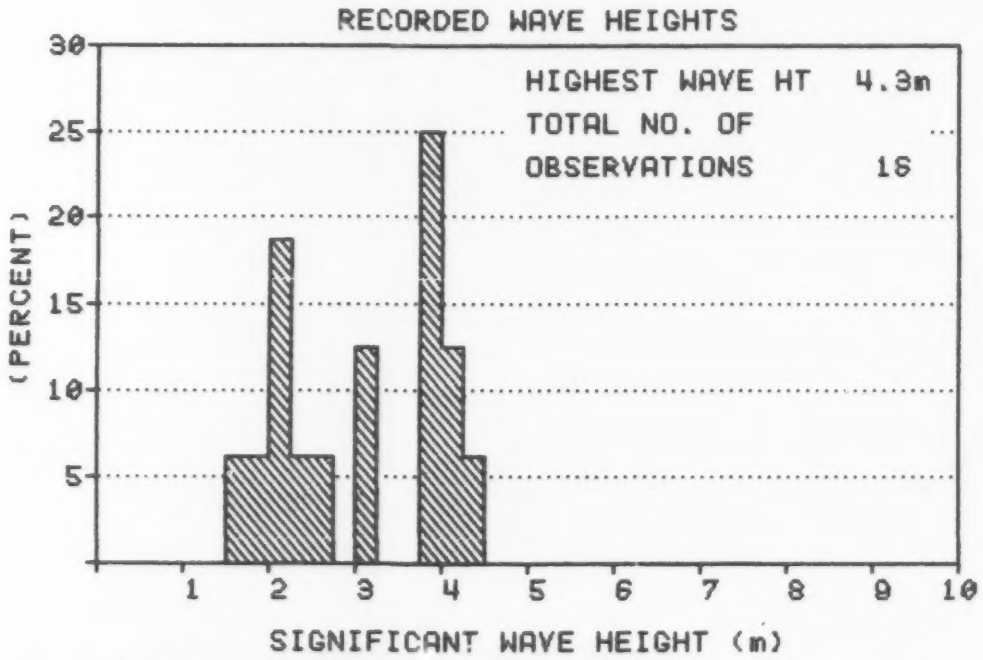


WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 73 12 24 12 - 73 12 28 12
LOCATION HINDCAST STA 9 / SEDCO H 91(3)



WAVE FILE W-SI.BAIRD.9



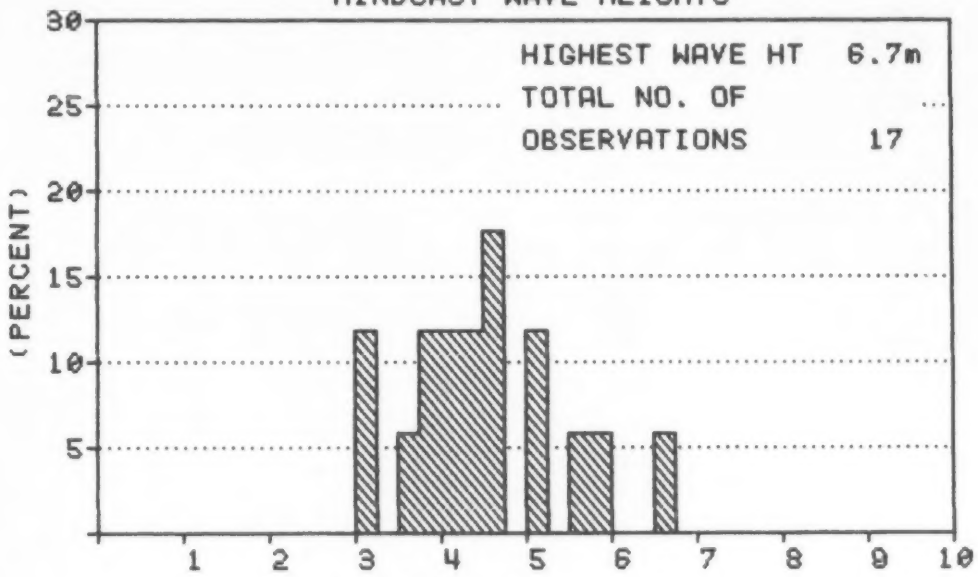
WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 73 12 28 12 - 73 12 30 12
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

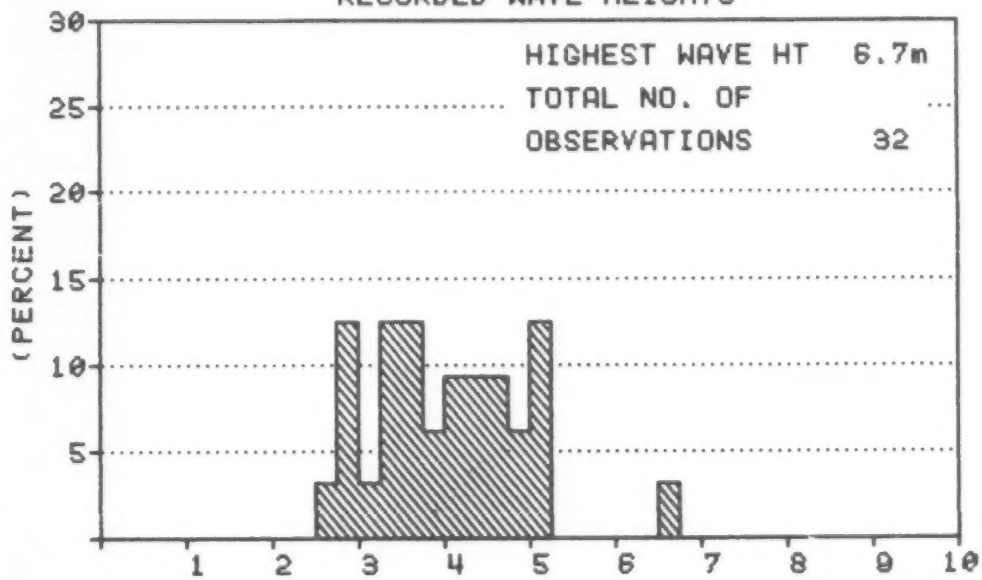
W.F.Baird Associates

HINDCAST WAVE HEIGHTS



WAVE FILE W←SI.BAIRD.6A

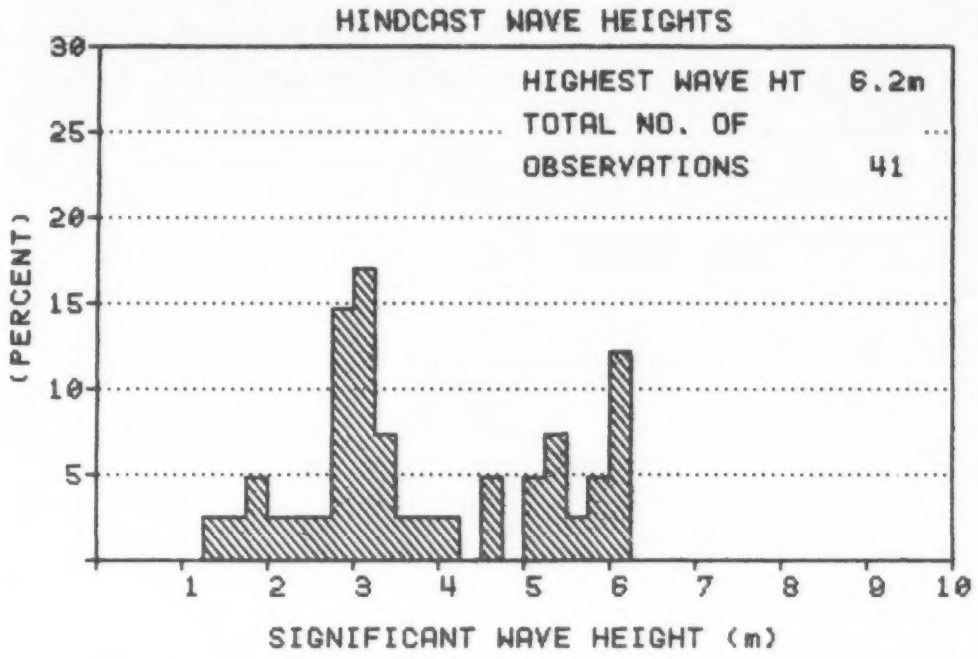
RECORDED WAVE HEIGHTS



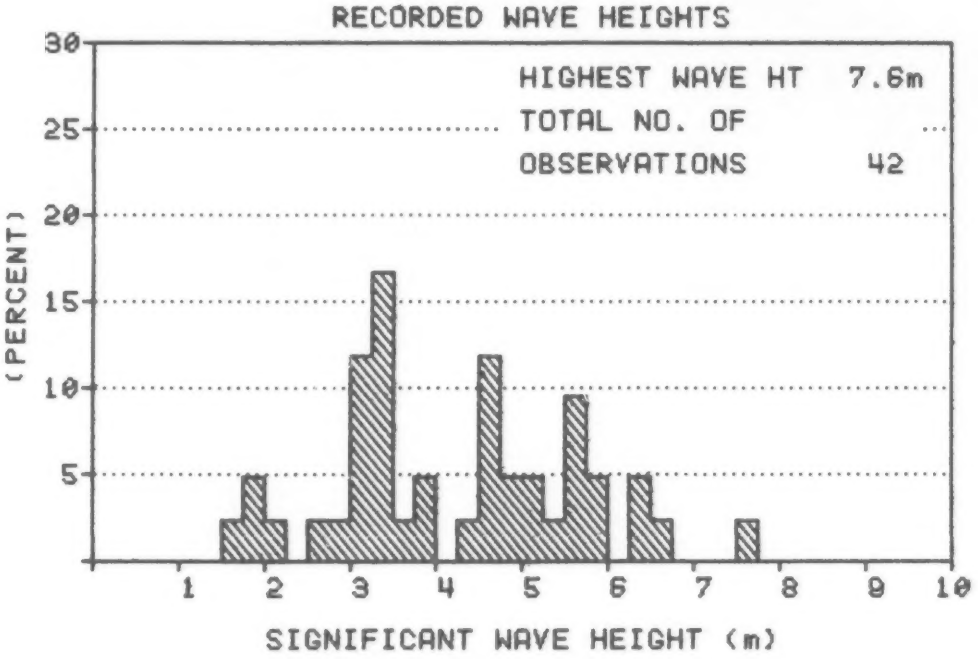
WAVE FILE W←MEDS.REC.90.GMT

STORM DURATION 73 12 24 12 - 73 12 28 12
LOCATION HINDCAST STA 6 / SEDCO J 90(3)

GFC



WAVE FILE W-SI.BAIRD.9

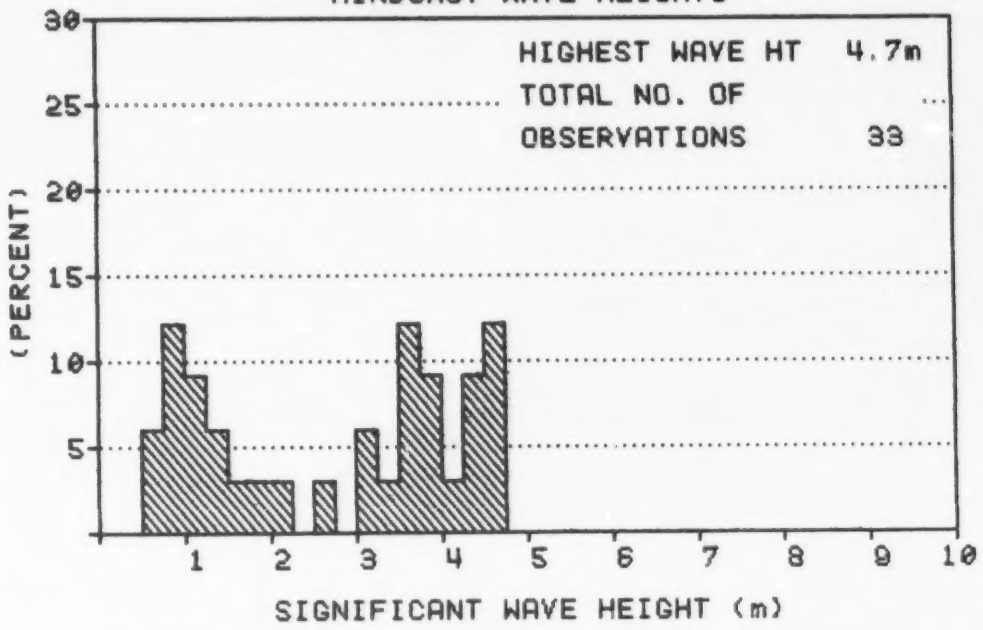


WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 74 01 01 24 - 74 01 06 24
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

HINDCAST WAVE HEIGHTS



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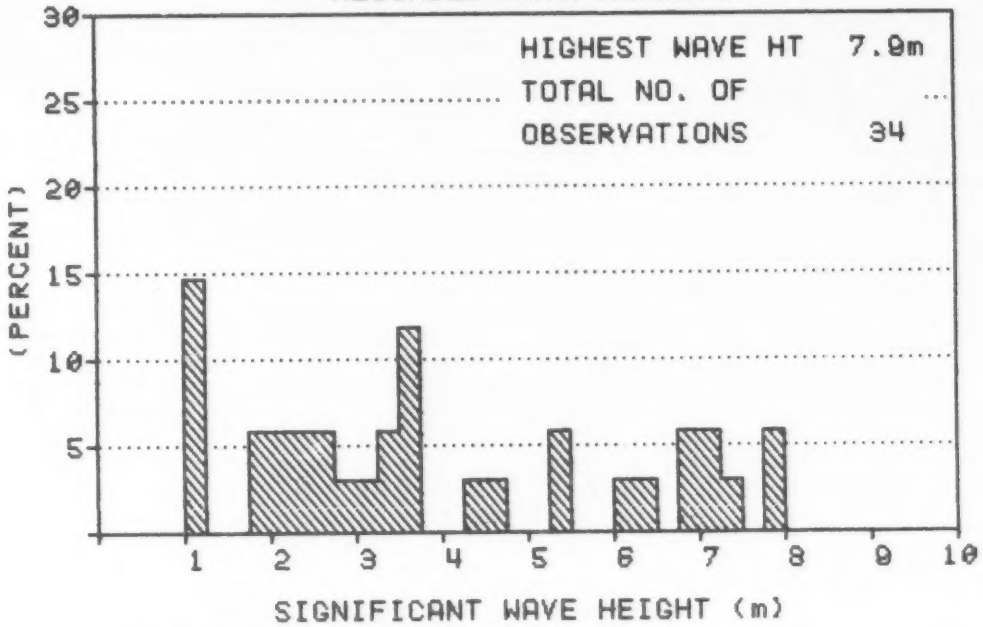
RECORDED WAVE HEIGHTS



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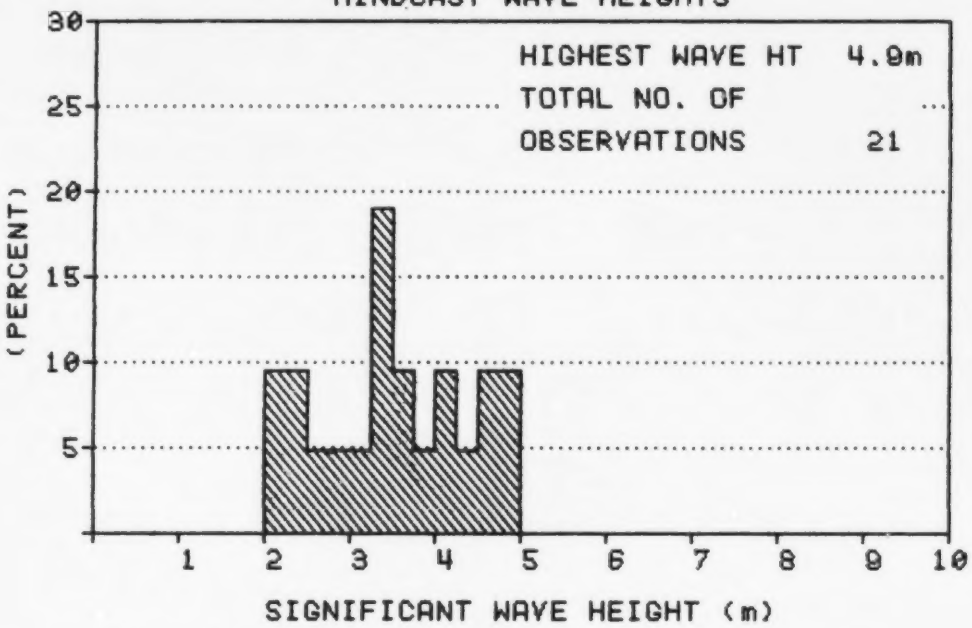
STORM DURATION 74 01 07 24 - 74 01 11 24
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

HINDCAST WAVE HEIGHTS



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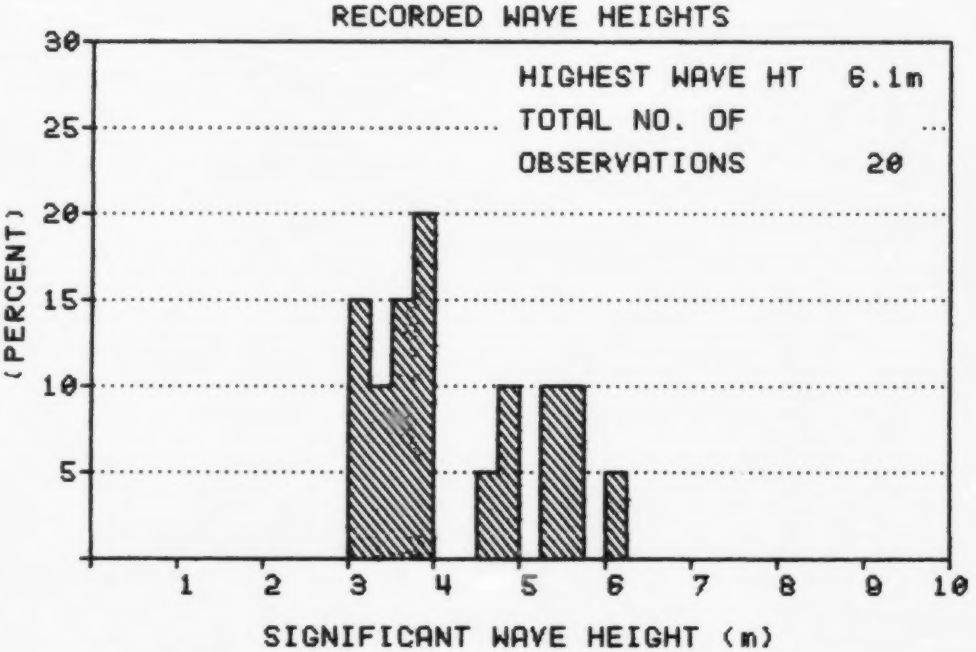
RECORDED WAVE HEIGHTS

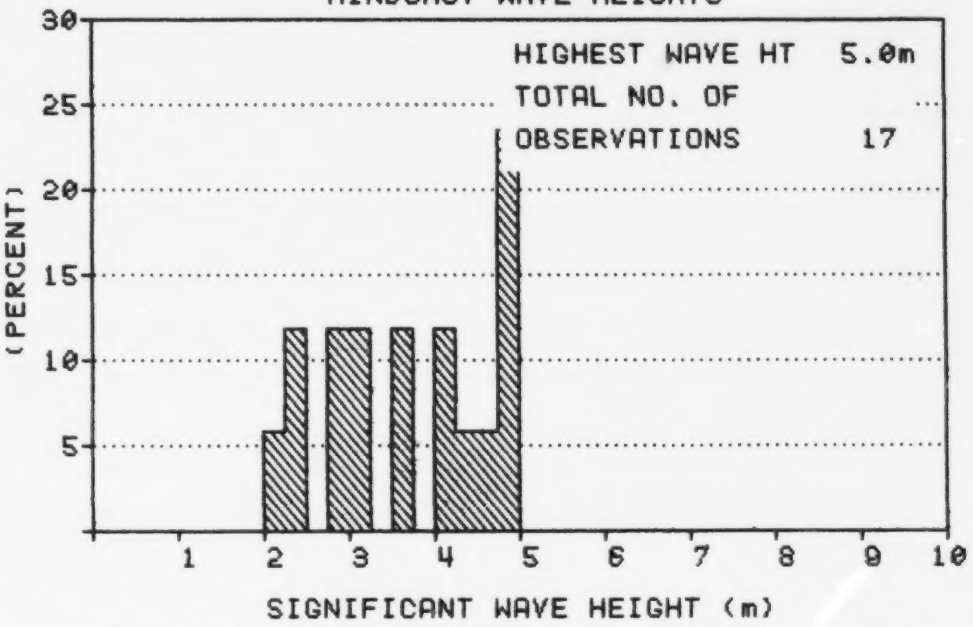


WAVE FILE W-MEDS.REC.01.GMT

STORM DURATION 74 01 14 24 - 74 01 17 12
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

HINDCAST WAVE HEIGHTS



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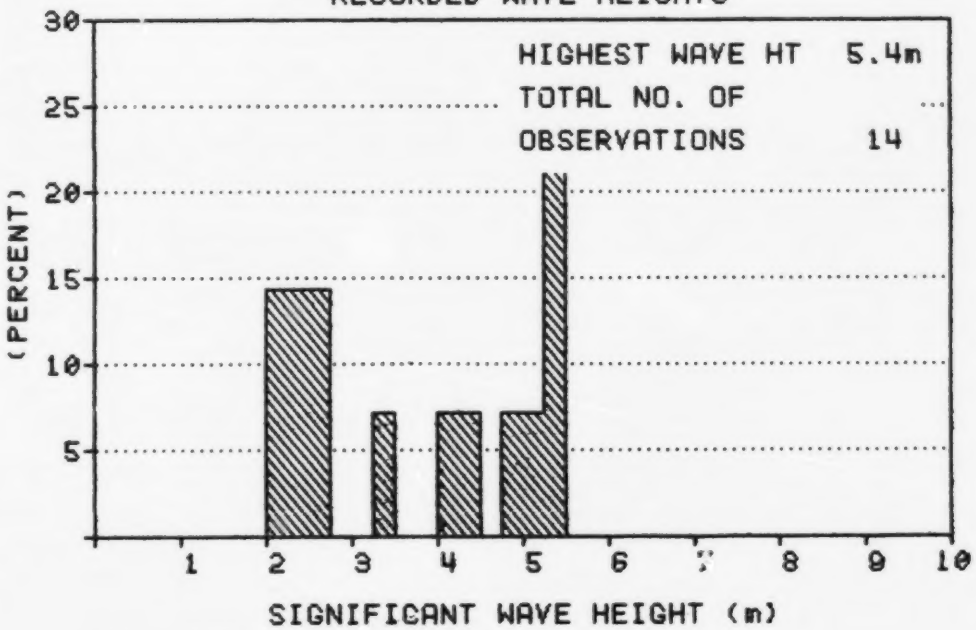

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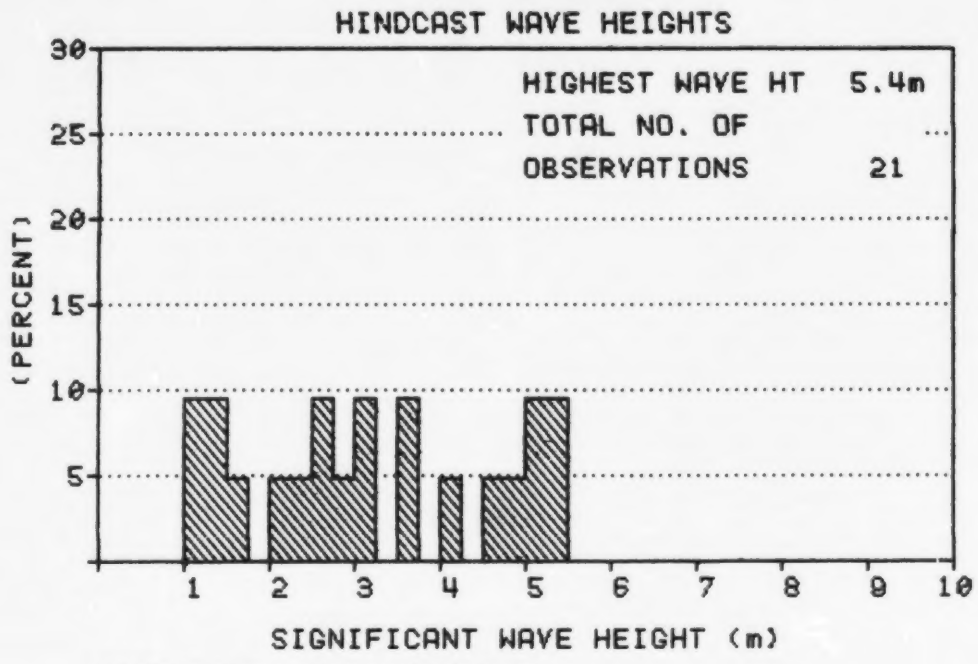
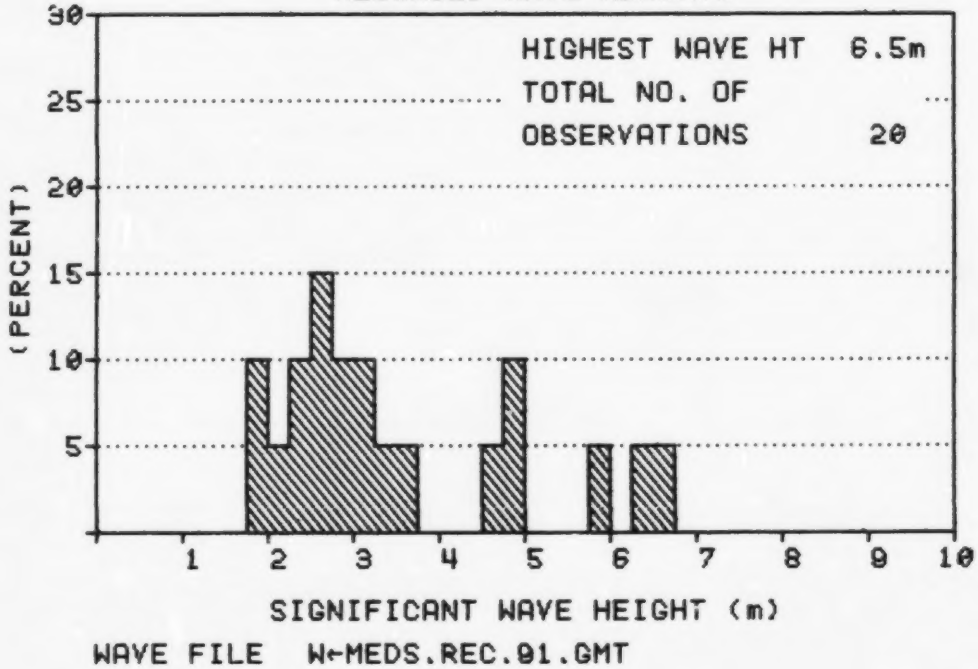
STORM DURATION 74 01 17 12 - 74 01 19 12
LOCATION HINDCAST STA 9 / SEDCO H 01(3)

GFC



WAVE FILE W←SI.BAIRD.9



WAVE FILE W←MEDS.REC.91.GMT

STORM DURATION 74 01 19 12 - 74 01 21 24
LOCATION HINDCAST STA 9 / SEDCO H 91(3)

GFC

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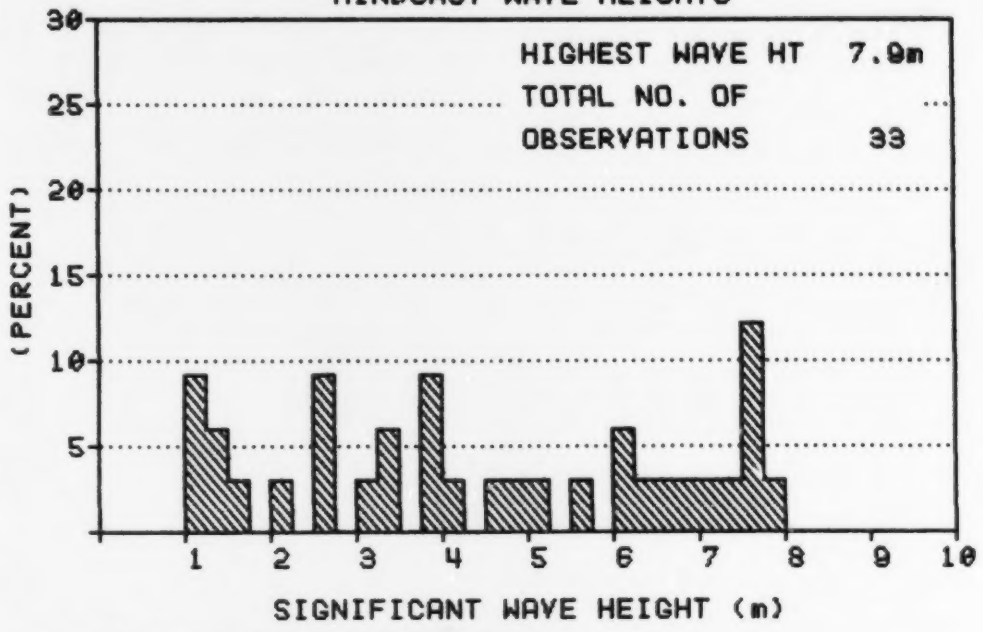
HINDCAST WAVE HEIGHTS



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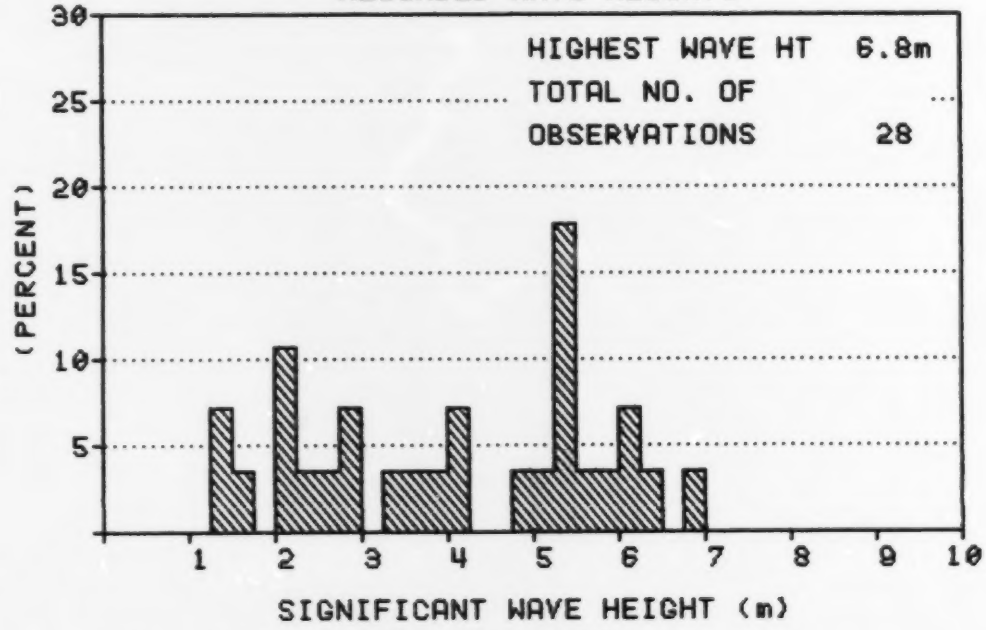
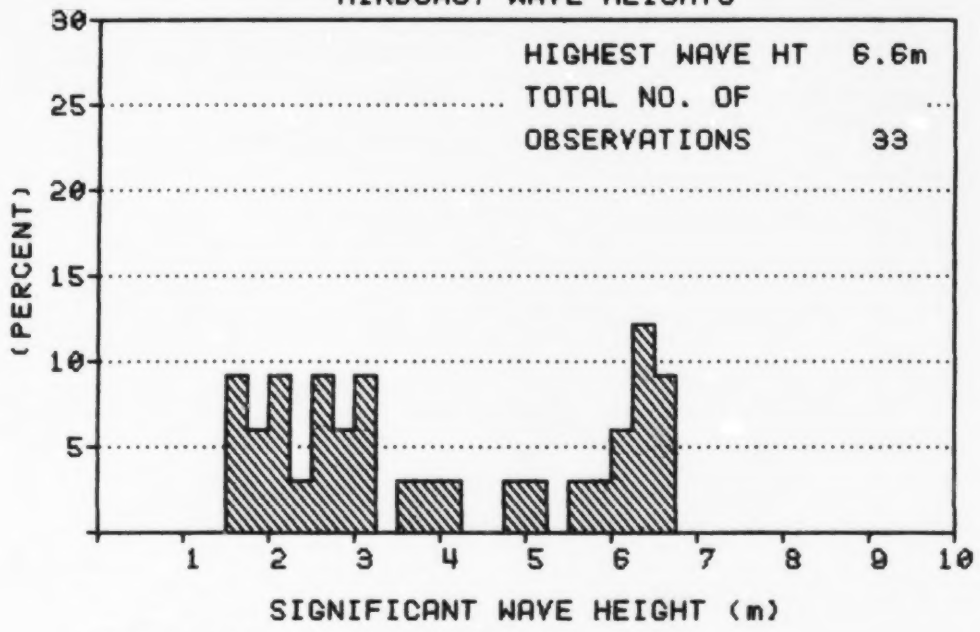


WAVE FILE W-MEDS.REC.01.GMT

STORM DURATION 74 02 03 24 - 74 02 07 24
LOCATION HINDCAST STA 10 / SEDCO H 91(4)

GFC

HINDCAST WAVE HEIGHTS



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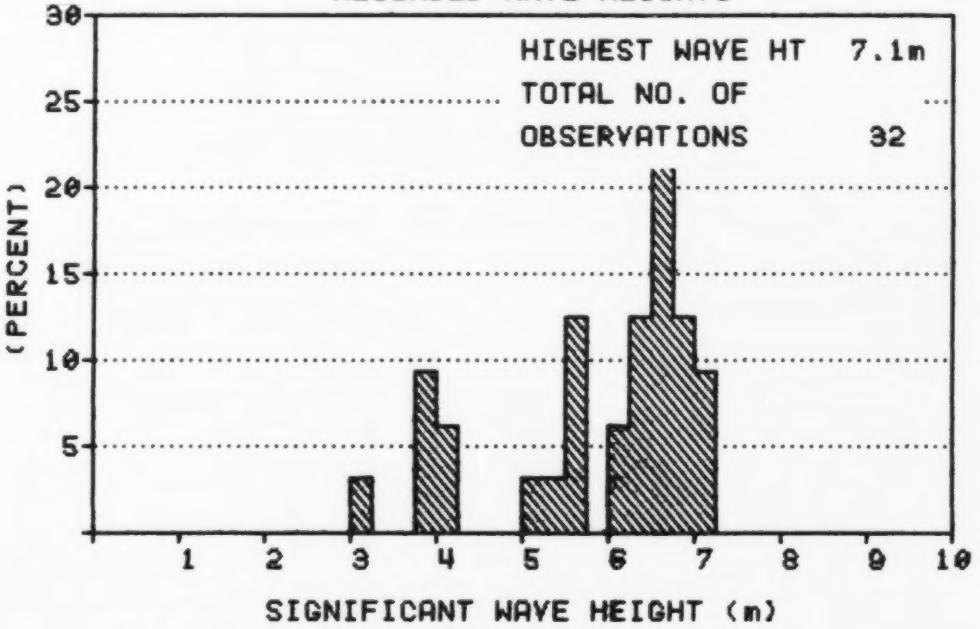


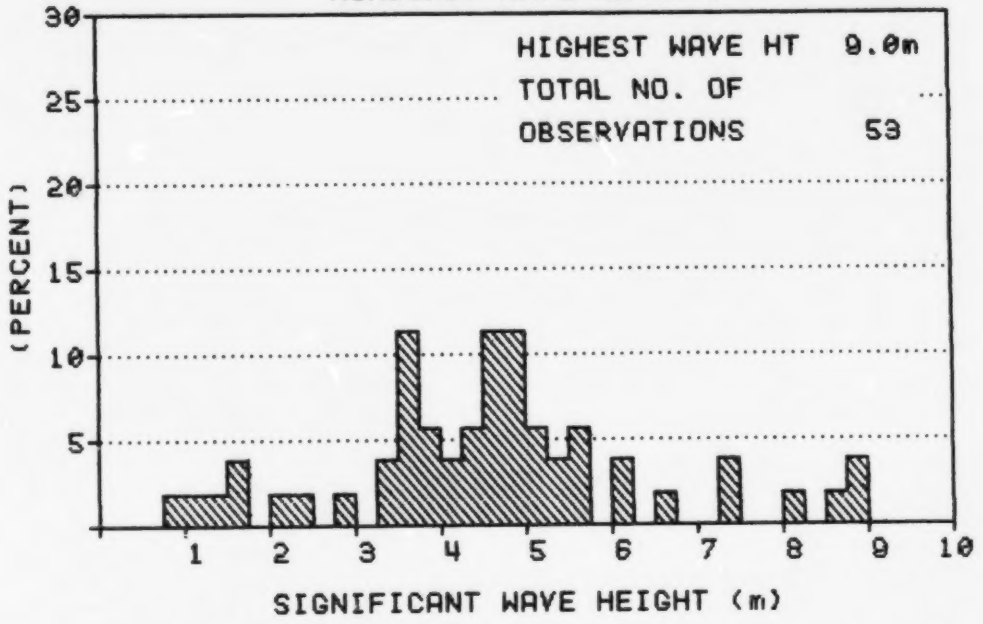
WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 74 02 22 12 - 74 02 26 12

LOCATION HINDCAST STA 10 / SEDCO H 91(4)

GFC

HINDCAST WAVE HEIGHTS



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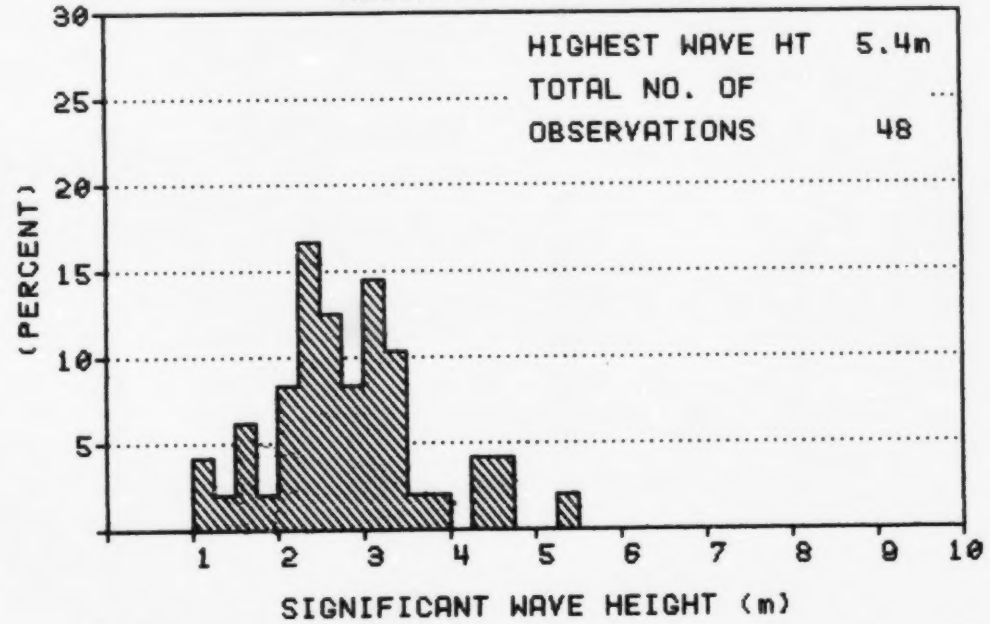

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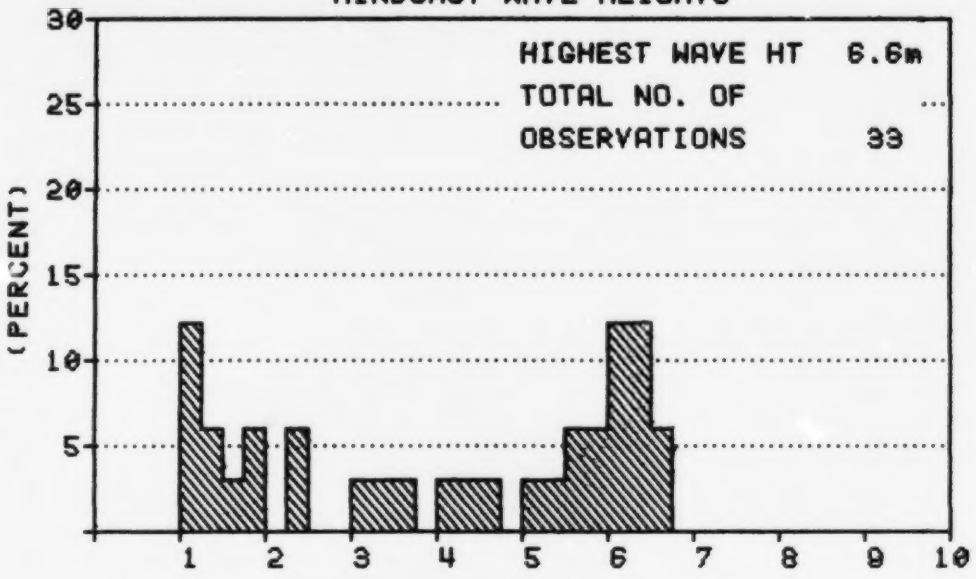
STORM DURATION 74 03 03 24 - 74 03 10 12
LOCATION HINDCAST STA 10 / SEDCO H 01(5)

HINDCAST WAVE HEIGHTS



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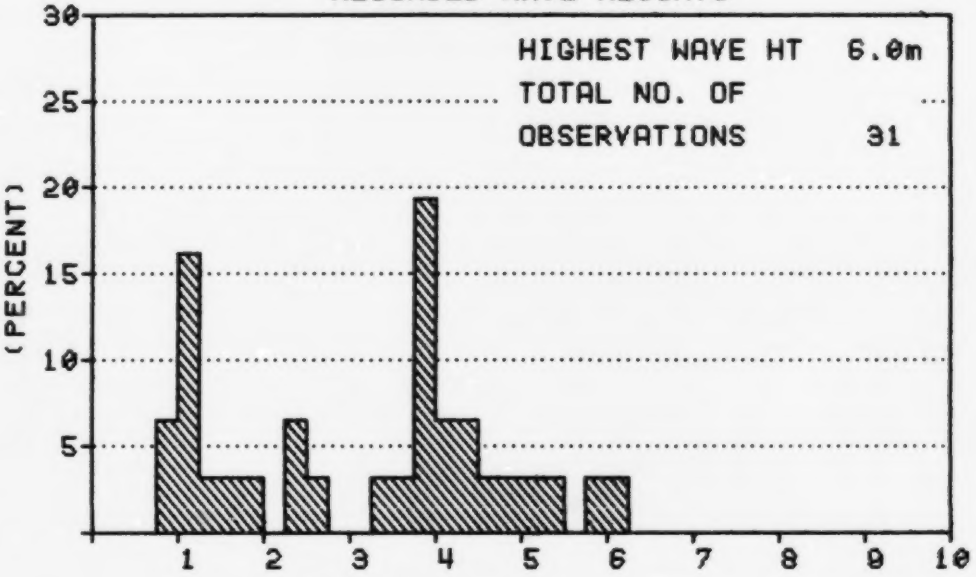

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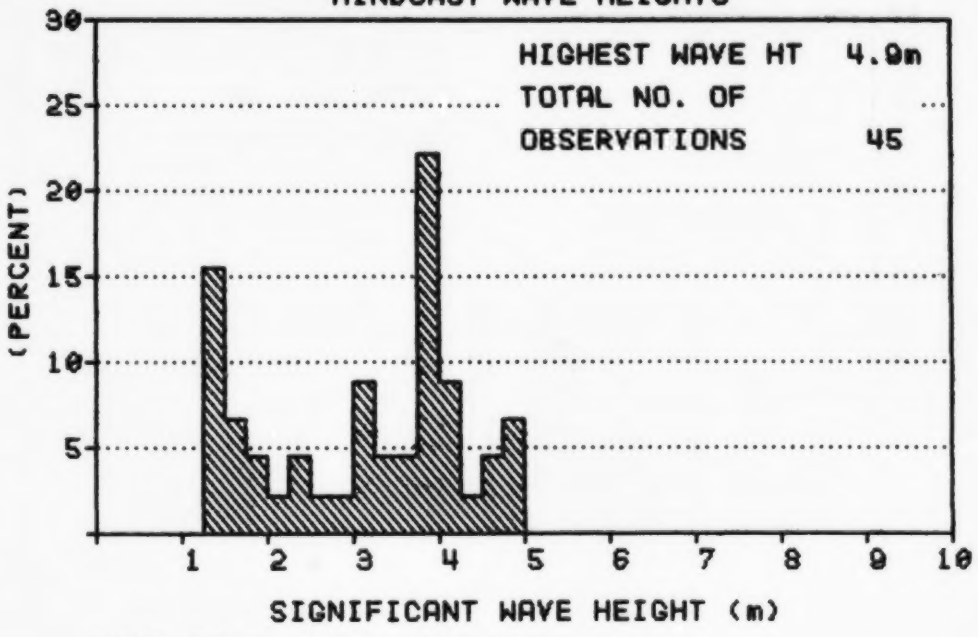
STORM DURATION 74 03 26 24 - 74 03 30 24
LOCATION HINDCAST STA 10 / SEDCO H 91(5)

GFC

HINDCAST WAVE HEIGHTS



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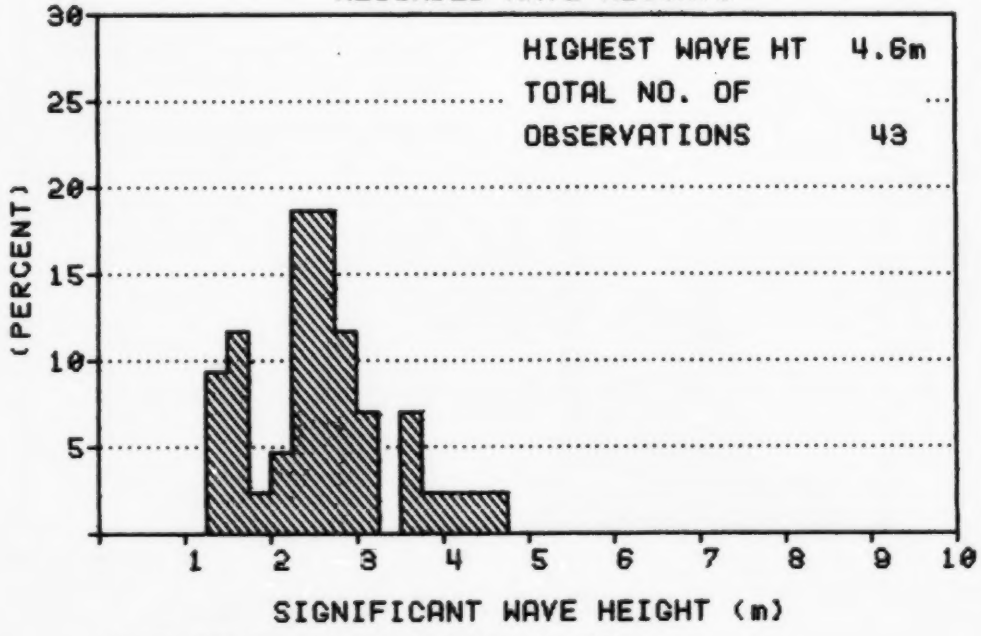
RECORDED WAVE HEIGHTS



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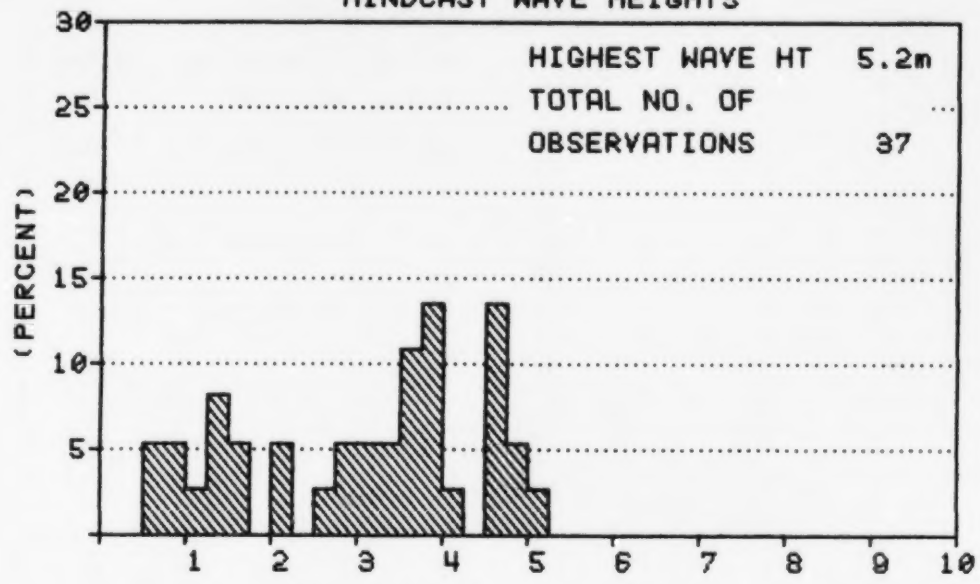
STORM DURATION 74 04 03 24 - 74 04 09 12
LOCATION HINDCAST STA 10 / SEDCO H 91(5)

GFC

HINDCAST WAVE HEIGHTS



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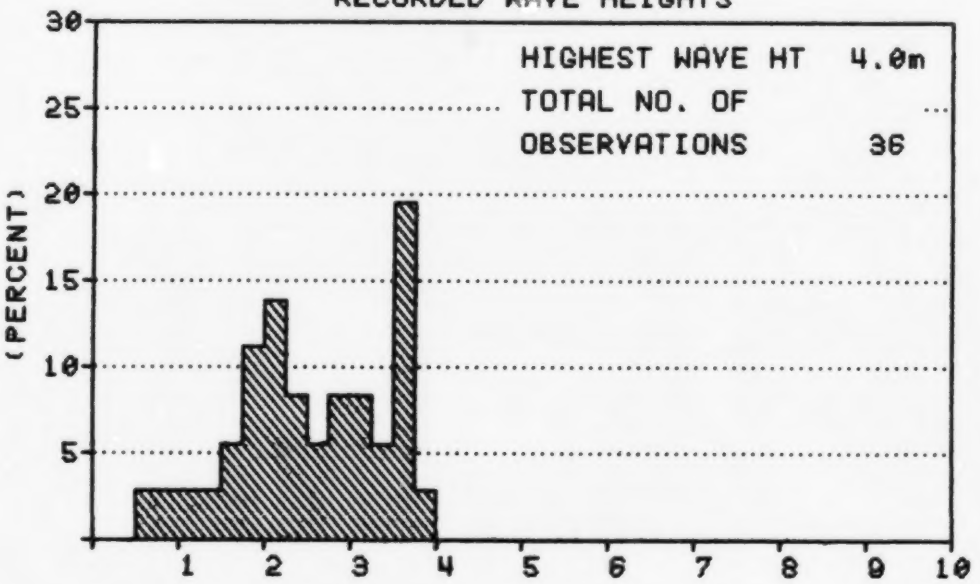
RECORDED WAVE HEIGHTS



WAVE FILE W←MEDS.REC.91.GMT

STORM DURATION 74 04 00 12 - 74 04 13 24
LOCATION HINDCAST STA 10 / SEDCO H 91(5)

GFC

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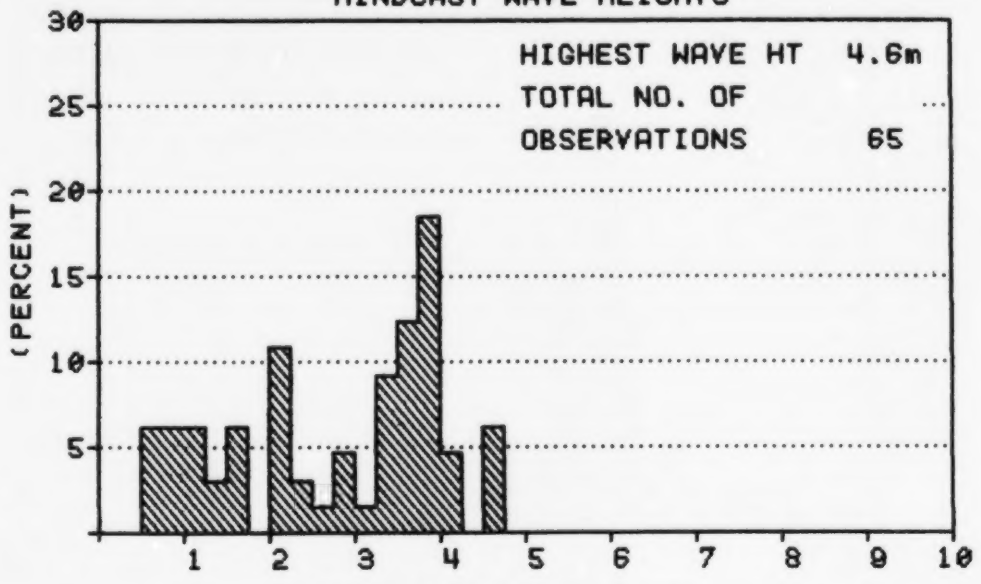
HINDCAST WAVE HEIGHTS



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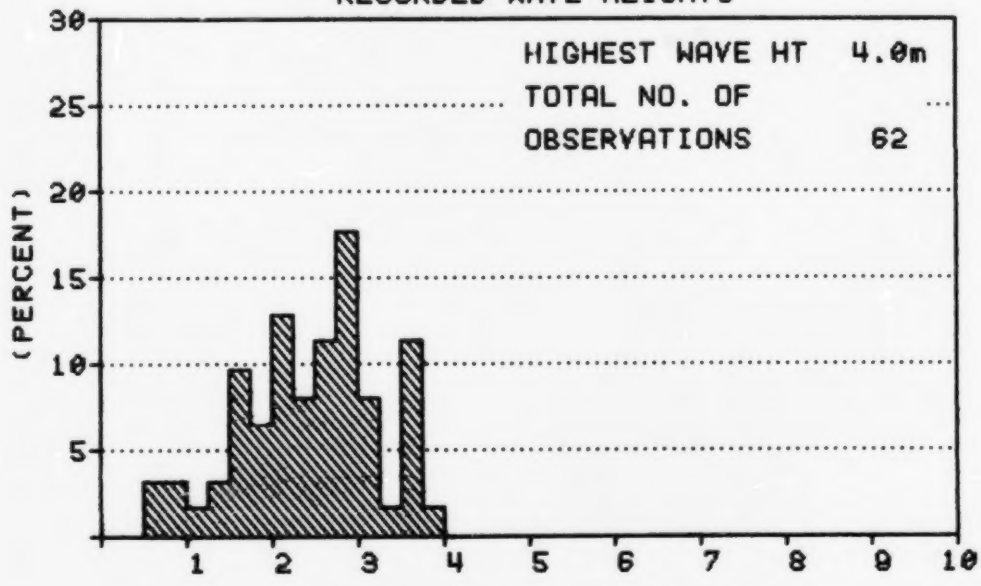
RECORDED WAVE HEIGHTS

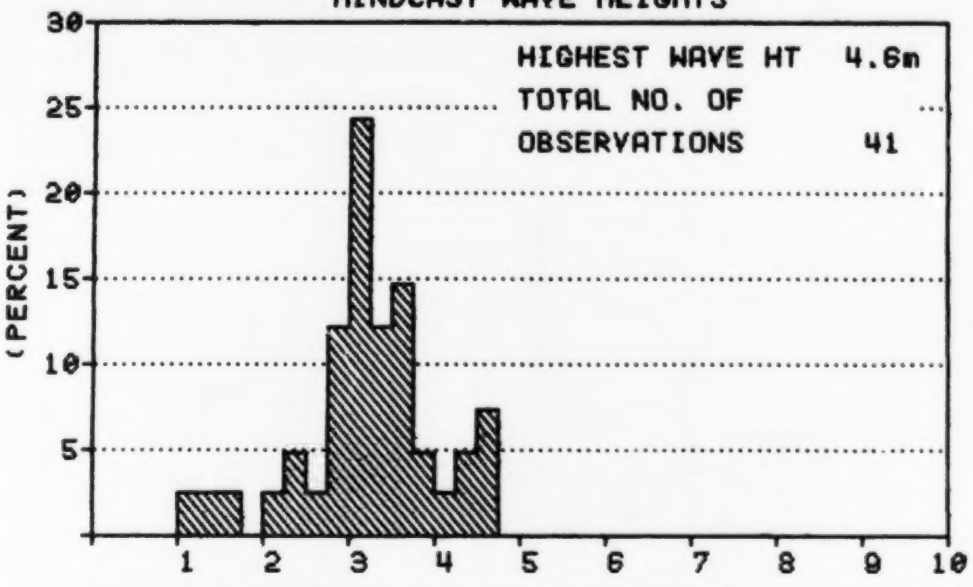


WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 74 04 10 24 - 74 04 18 24
LOCATION HINDCAST STA 10 / SEDCO H 91(5)

GFC

HINDCAST WAVE HEIGHTS



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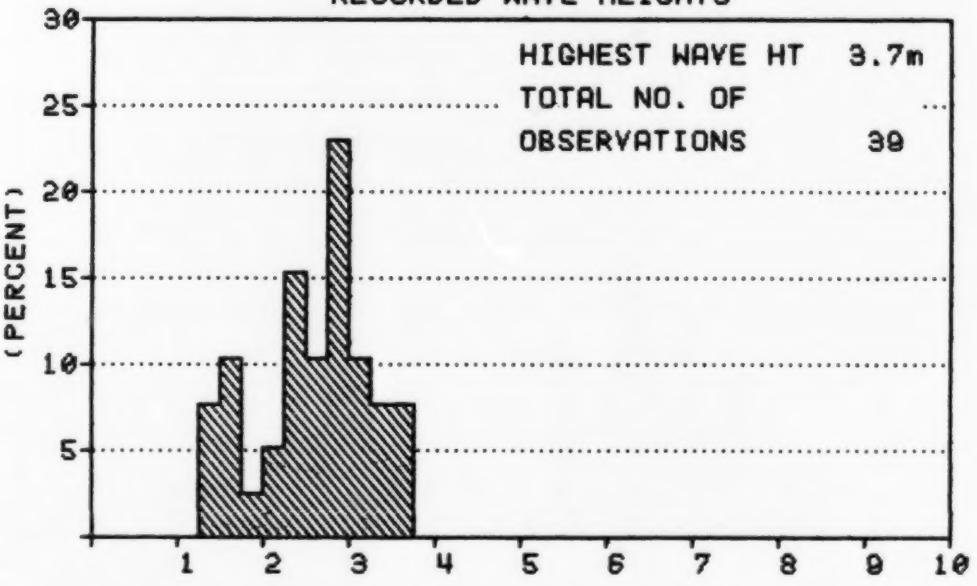
RECORDED WAVE HEIGHTS



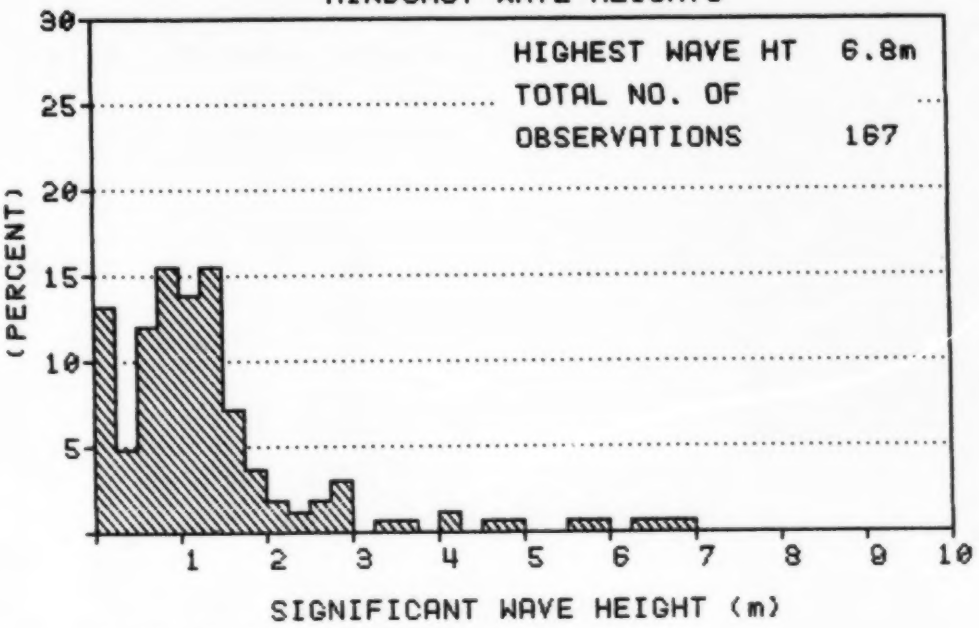
WAVE FILE W-MEDS.REC.91.GMT

STORM DURATION 74 04 22 24 - 74 04 27 24
LOCATION HINDCAST STA 10 / SEDCO H 91(5)

GFC

W.F.Baird Associates

HINDCAST WAVE HEIGHTS



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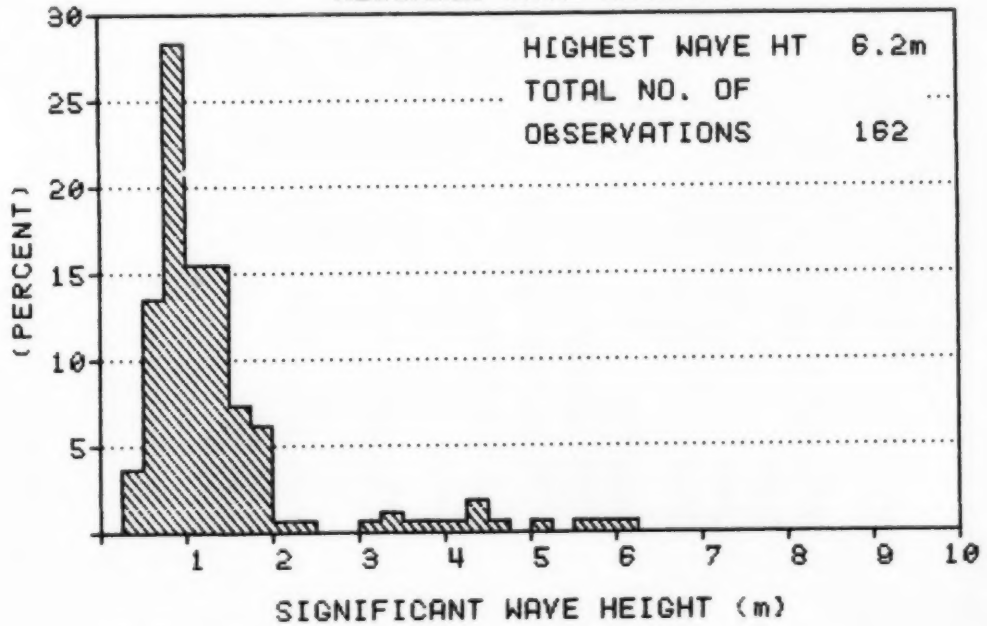
RECORDED WAVE HEIGHTS



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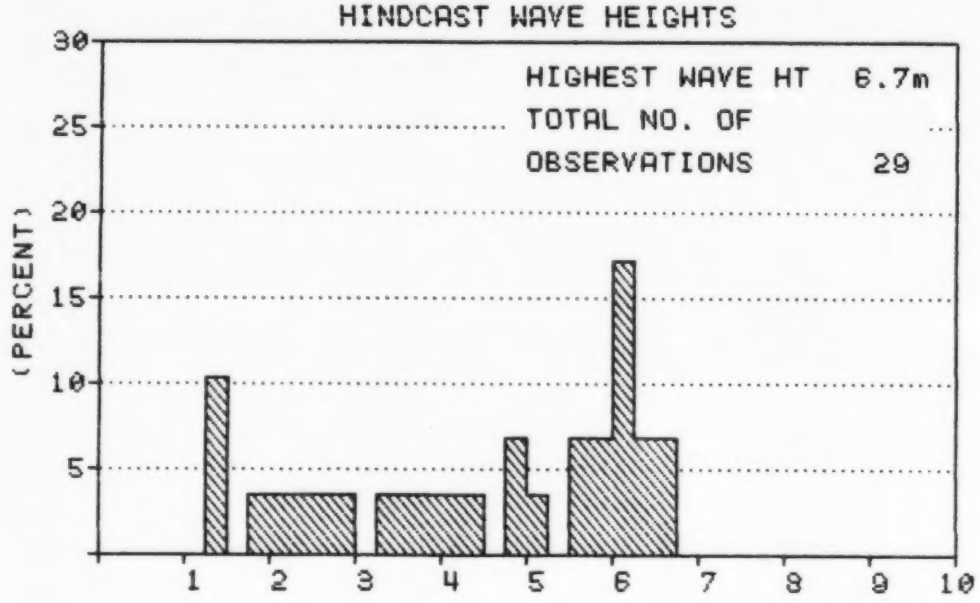
STORM DURATION 74 05 26 24 - 75 05 30 24
LOCATION HINDCAST STA 12 / SEDCO H 01(6)

GFC

HINDCAST WAVE HEIGHTS



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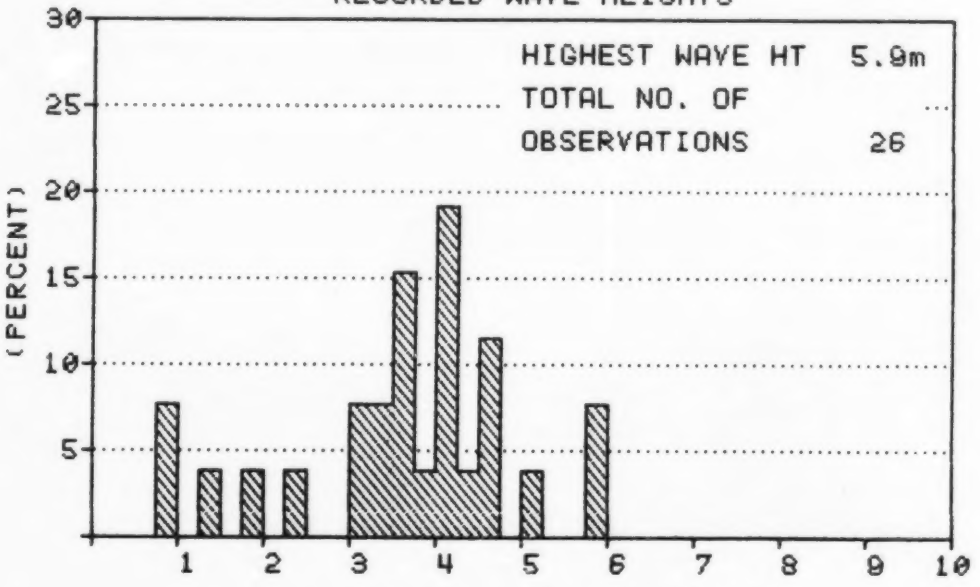
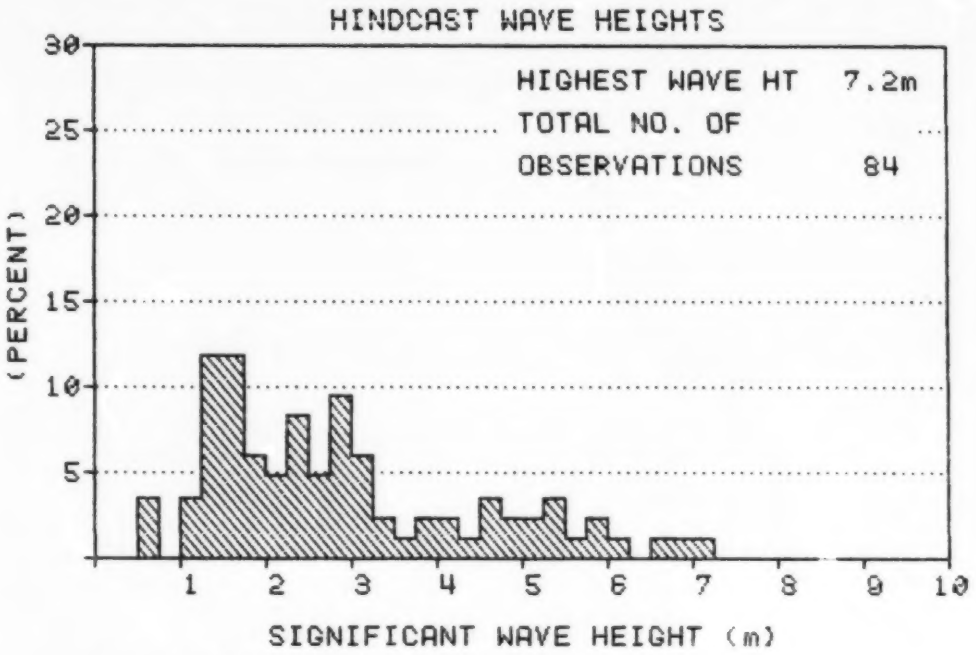
RECORDED WAVE HEIGHTS



WAVE FILE W←MEDS.REC.91.GMT

STORM DURATION 74 03 10 12 - 74 03 13 24
LOCATION HINDCAST STA 10 / SEDCO H 91(5)

W.F.Baird Associates



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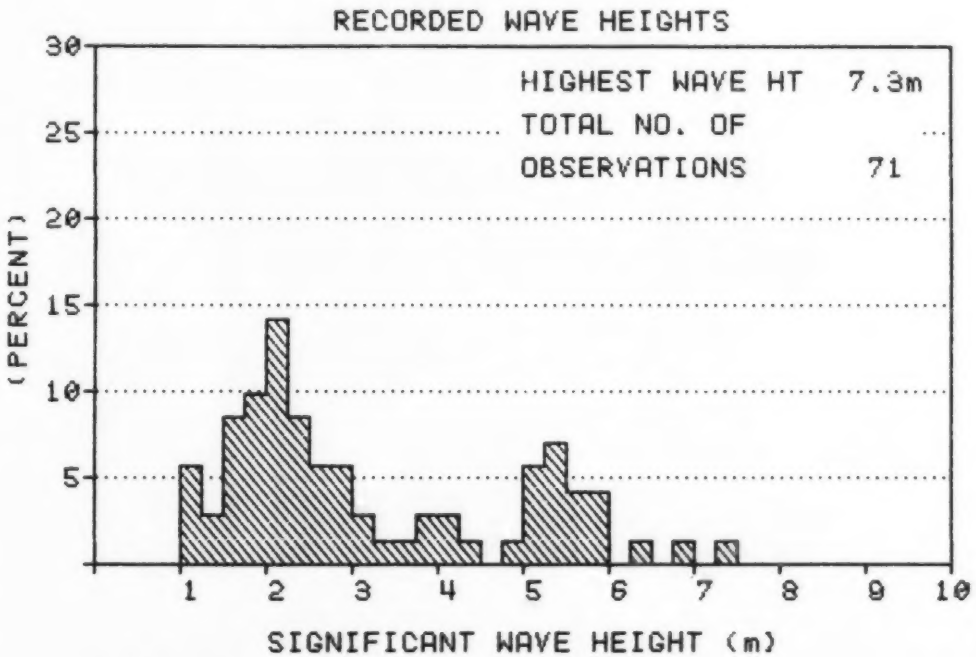
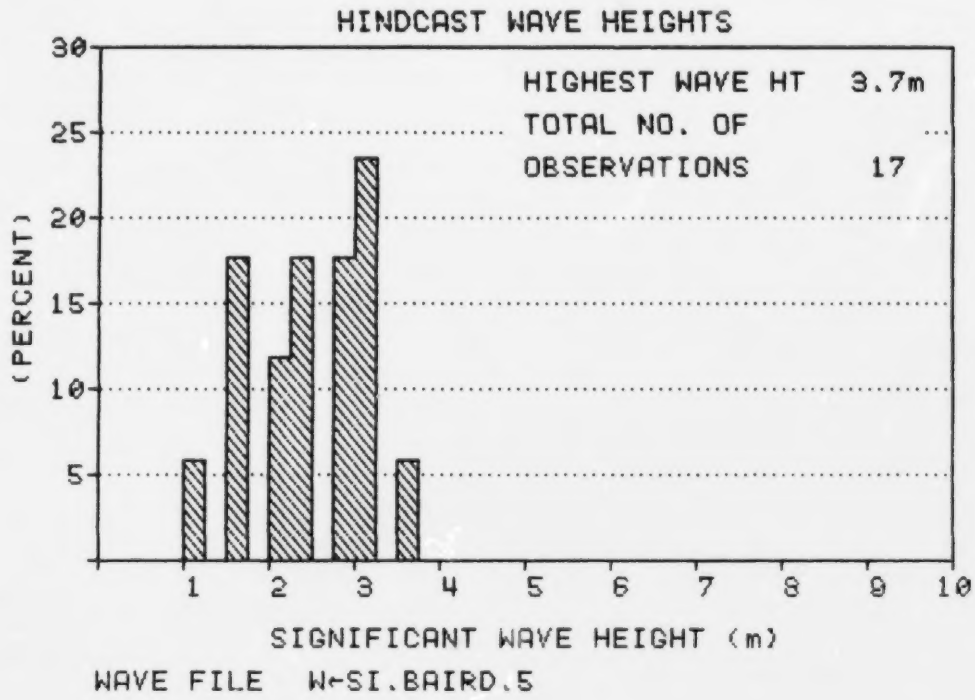


WAVE FILE W-MEDS.REC.94.GMT

STORM DURATION 74 00 25 24 - 75 00 29 24
LOCATION HINDCAST STA 5 / HAVDRILL 94

GFC



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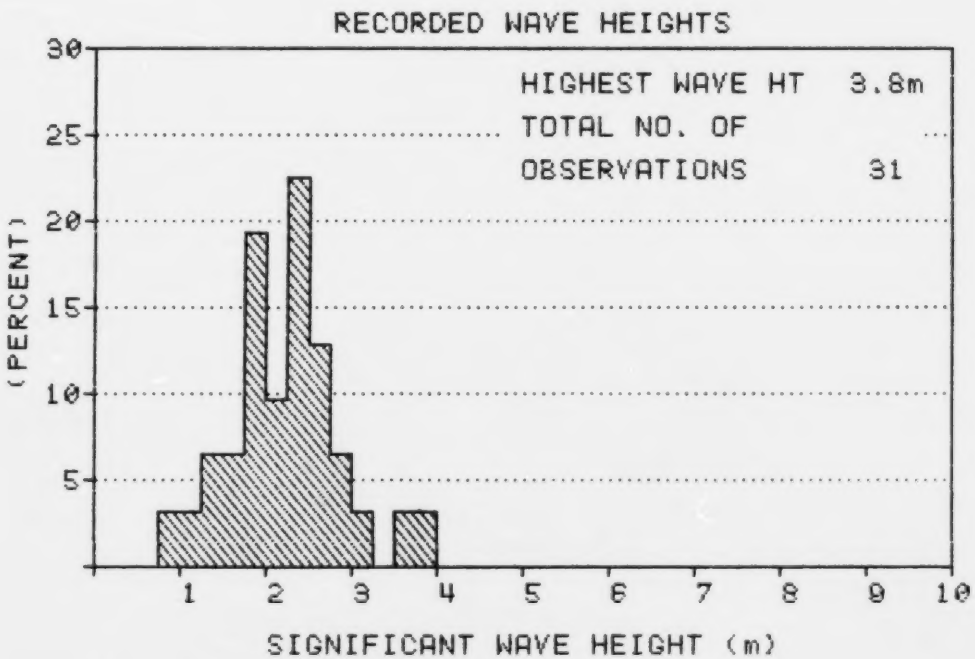
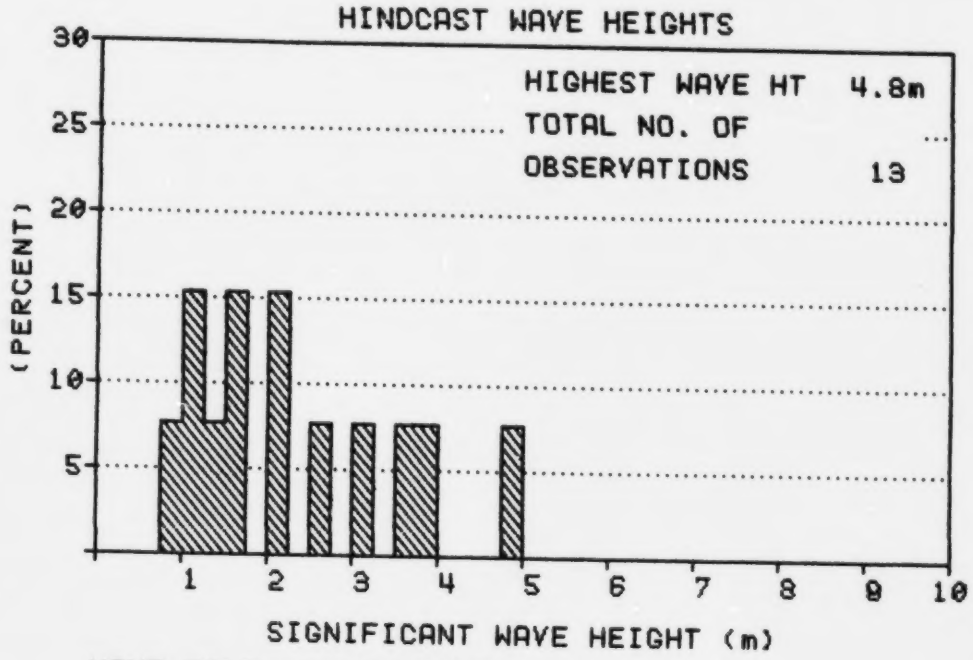


WAVE FILE W-MEDS.REC.90.GMT

STORM DURATION 75 08 18 24 - 75 08 22 24

LOCATION HINDCAST STA 5 / SEDCO J 90(9)

GFC



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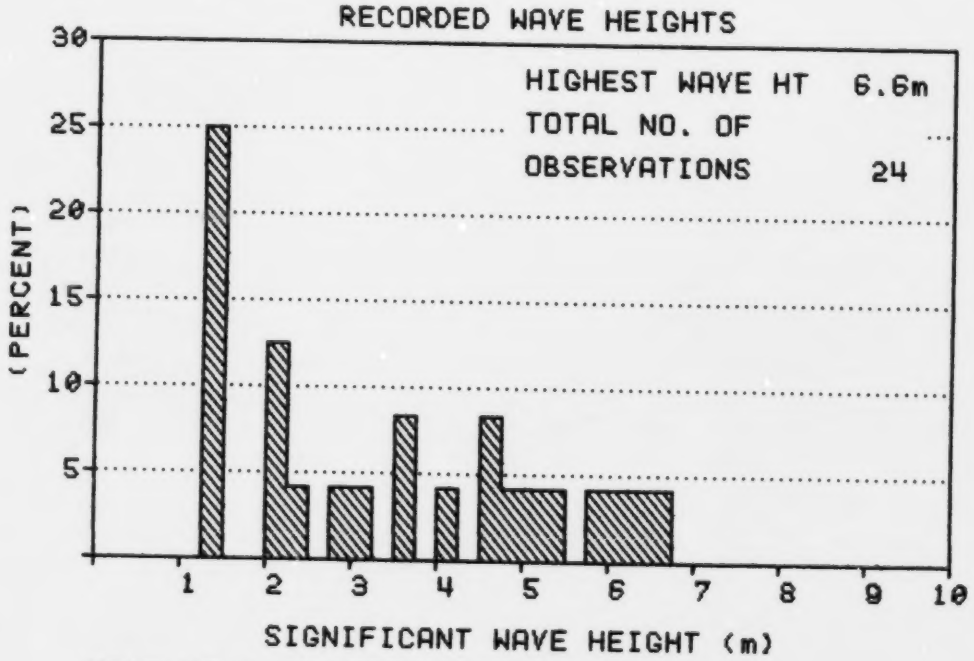

WAVE FILE W←MEDS.REC.90.GMT

STORM DURATION 75 08 22 24 - 75 08 25 24
LOCATION HINDCAST STA 5 / SEDCO J 90(9)

GFC